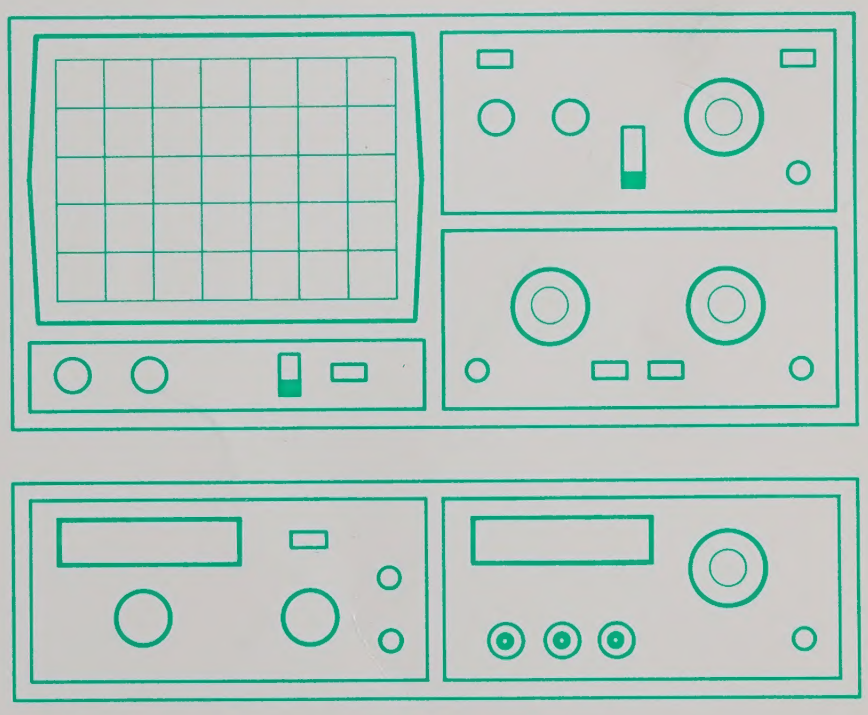
HAMEG
Instruments

MANUAL

Oscilloscope HM208



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Oscilloscope HM208

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HAMEG OSCILLOSCOPE HM 208

Specification

Normal Operating Modes

Channel I, Channel II, Channel I and II alternate or chopped (chop freq. ≈ 0.5 MHz), sum or difference: Cannel II ± Channel I.
X-Y mode: same sensitivity in both directions.

Vertical Deflection (Y)

Bandwidth of both channels:
DC to 20 MHz (−3 dB) in the normal mode.
Risetime: 17.5 ns. Overshoot: max. 1 %.
Deflection coefficients: 12 calibrated steps, 5 mV/cm to 20 V/cm in 1-2-5 sequence, with variable control 2.5:1 up to at least 50 V/cm.
Accuracy in calibrated position: ±3 %.
Y-Magnification x5 calibrated to **1 mV/cm**, bandwidth: DC to 5 MHz (−3 dB).
Input impedance: 1 MΩ II 30 pF.
Input coupling: DC-AC-GND.
Input voltage: max. 400 V (DC + peak AC).

Timebase

Time coefficients: 18 calibrated steps, 0.2 µs/cm to 0.1 s/cm in 1-2-5 sequence, with variable control 2.5:1 up to at least 0.25 s/cm, with **X-Magnification x10** (±5 %) to **20 ns/cm**.
Accuracy in calibrated position: ±3 %.
Trigger system: Auto or Normal. LED indication.
Slope: positive or negative.
Sources: Ch. I, Ch. II, line, ext., ext. ÷10.
Coupling: AC, DC, HF, LF (TV frame).
Threshold: internal 5 mm, external 50 mV.
Bandwidth: DC to at least 40 MHz.
Ext. trig. input: max. 100 V pp, imped. 1 MΩ II 30 pF.

Horizontal Deflection (X)

Bandwidth: DC to 2 MHz (−3 dB).
Input: via Channel II (see Y deflection spec.).
X-Y phase shift: <3° up to 150 kHz.

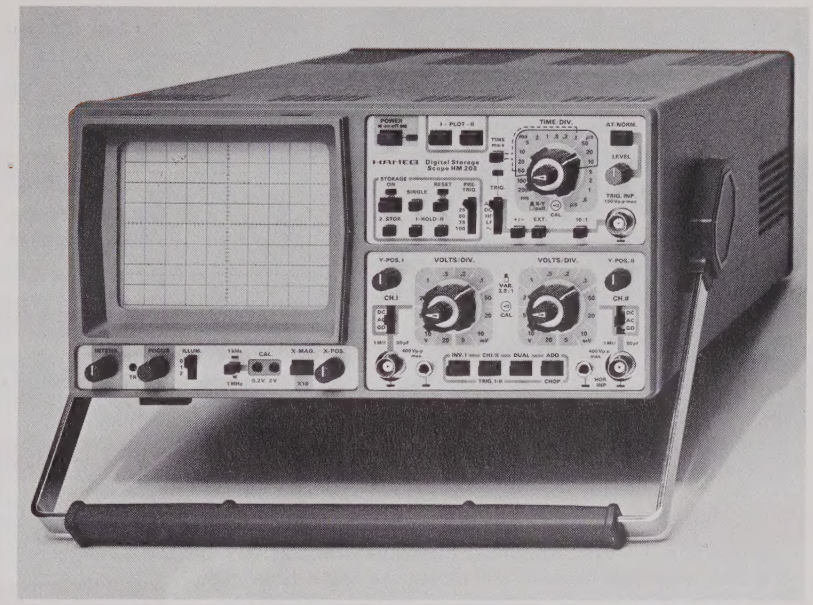
Digital Storage

Memory: 4096 x 8 bit. Ch. I: 2048 points/pattern. 2-channel: 1024 points/pattern. Backing memory: 1 x 2048 points or 2 x 1024 points.
Clock rate: Channel I max. **20 MHz**, Channel I and Channel II: max. 10 MHz.
Vertical resolution: 256 points for 10 cm.
Horizontal resolution: 1024 points for 10 cm.
Modes: Roll, Refresh, Single, X-Y operation, addition: Ch. II ± Ch. I, Hold Ch. I, Hold Ch. II.
Pre-Trigger: 25-50-75-100 %. Time exp.: 10 x.
Plotter output: Y 0.1 V/cm, X 0.1 V/cm (±10%) for the stored signal of CH.I or CH.II.
X and Y output impedance: 100 Ω.
Plotter writing speed selectable in 3 steps:
2-channel = 5 s/cm to 20 s/cm,
1-channel = 10 s/cm to 40 s/cm (max. clock rate).
Pen lift command: TTL and CMOS compatible.

General Information

Cathode-ray tube: D14-370 P31/113R, approx. 14 kV, rect. screen **8x10 cm**, int. graticule, quick heating.
Graticule illumination: three-position switch.
Trace rotation: adjustable on front panel.
Calibrator: square-wave generator ≈ 1 kHz/1 MHz for probe compensation. Output 0.2 V and 2 V ±1%.
Regulated DC power supplies: all voltages.
Protective system: Safety Class I (IEC 348).
Line voltages: 110, 125, 220, 240 V AC..
Permissible line fluctuation: ±10 %.
Line frequency range: 50 to 60 Hz.
Power consumption: approx. 46 Watts.
Weight: approx. 9 kg. Color: techno-brown.
Cabinet (mm): **W** 285, **H** 145, **D** 380.
With lockable tilt handle.

Subject to change.



20 MHz Digital Storage Oscilloscope

Y: 2 channels, DC-20 MHz, max. sensitivity 1 mV/cm;
X: 0.25 s/cm-20 ns/cm incl. x10 magnification, trig. to 40 MHz.
Storage: max. clock rate 20 MHz; Single and X-Y operation.

The new **HM208** can be used as a normal 20 MHz realtime oscilloscope or as a **digital storage instrument** featuring **20 MHz maximum digitizing rate** in single-channel, or 10 MHz in dual-channel storage mode.

All operating modes, such as single- or dual-channel operation, add- or differential mode, X- and Y-expansion, X-Y operation, as well as the **various trigger facilities** are also **available in storage operation**. The nature of digital storage offers still many more display possibilities, which are fully taken advantage of in the **HM208.** Single-shot mode, for example, enables the capture of periodic and aperiodic one time events. As a result of intermediate storage, the reduction of trace brightness, normally observed at higher frequencies, is avoided.

Extremely low-frequency events can be stored, where the waveform is no longer indicated by a moving dot, but is now **displayed in its entirety**. In **roll mode** the HM208 functions very similar to a chart recorder, with the signal running slowly from right to left with continous trace. With the HM208, **pre-trigger history** can be set to four different values, max. 100 %. A periodically repeating signal acquisition is possible in the **refresh-mode**. In X-Y operation, characteristic curves, transfer loci, and Lissajous figures can be stored at low frequencies.

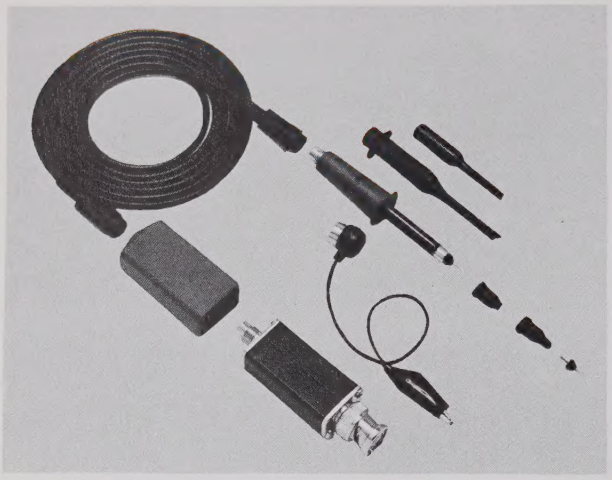
A special **background memory** provides the possibility of storing a reference signal, while another signal occupies the main memory with equal resolution. At any time and as often as required, **these signals can be displayed on the screen**. A 14 kV CRT ensures bright and clear displays in all modes.

Stored waveforms may be recorded using a chart- or X-Y recorder. **Readout speed is variable** to match the required degree of resolution.

An **IEC-Bus option** is available (talk only) to transmit stored waveforms to a listener or controller.

Accessories optional

Probes: 1X, 10X, 10X(HF), 100X, 1X/10X; demodulating probe; test cables BNC-BNC and banana-BNC; 50 Ω BNC termination; viewing hood; carrying case; IEC-Bus for HM208.



Modular Probes

The clear advantage over ordinary probes are field replaceable parts and the HF-compensation feature on the 10:1 attenuator probes. For the first time, probes in this price range allow adjustments of their HF-characteristics to match individually the input impedance of each scope. This is particularly important for scopes with higher bandwidths (>50MHz), as otherwise strong overshoot or rounding may occur, when measuring fast-rising square waves. An exact HF-compensation, however, is only possible with square-wave generators having a risetime <5ns. Most HAMEG scopes already feature such a calibration generator. For other oscilloscopes, it is available as accessory item HZ60. At present the following Modular Probes are available:

Type	HZ50	HZ51	HZ52	HZ53	HZ54
					selectable
Attenuation Ratio	1:1	10:1	10:1 (HF)	100:1	1:1 / 10:1
Bandwidth min. (MHz)	30	150	250	150	10 / 150
Risetime (ns)	11	<2	<1.4	<2	35/<2
Inp. Capacitance (pF)	45	16	16	6,5	40/18
Inp. Resistance (MΩ)	1	10	10	100	1/10
Inp. Voltage max. (V_p)	600	600	600	1200	600
Cable Length (m)	1.2	1.2	1.5	1.5	1.2

Demodulator Probe HZ55

Special probe for AM-demodulation and wobbulator measurements. HF-Bandwidth 100kHz - 500MHz (±1dB). AC Input Voltage 250mV - 50V_{rms}. DC Isolation Voltage 200V DC including peak AC. Cable length 1.2m.

Conventional Probes

These popular standard probes are well suited for all oscilloscopes up to 20MHz bandwidth (HZ37 only with HF adjustment facility).

Typ	HZ30	HZ35	HZ36	HZ37	HZ39
			selectable	selectable	selectable
Attenuation Ratio	10:1	1:1	1:1 / 10:1	1:1 / 10:1	1000:1
Bandwidth min. (MHz)	100	10	10 / 100	10 / 150	1
Risetime (ns)	3.5	35	35 / 3.5	20 / 3.2	50
Inp. Capacitance (pF)	13	47	47/13	44/13	3
Inp. Resistance (MΩ)	10	1	1/10	1/10	500
Outp. Resistance (MΩ)	1	1	1	1	1/10
Inp. Voltage (max. V_p)	600	600	600	600	15000
Cable Length (m)	1.5	1.5	1.5	1.2	1.5

Test Cable Banana–BNC HZ32

Coaxial test cable; length 1.15m, characteristic impedance 50Ω. Cable capacitance 120pF. Input voltage max. 500V_p.

Test Cable BNC–BNC HZ34

Coaxial test cable; length 1.2m, characteristic impedance 50Ω. Cable capacitance 126pF. Input voltage max. 500V_p.

Adapter Banana–BNC HZ20

Two 4mm binding posts (19mm between centers) to standard BNC male plug. Input voltage max. 500V_p.

50Ω Through-Termination HZ22

For terminating systems with 50Ω characteristic impedance. Maximum load 2W. Max. voltage 10V_{rms}.

Carrying Cases

For HM203-1 and HM203-3	HZ42
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For HM307, HZ62 and HZ64	HZ44
For HM103	HZ45
For HM203-4, HM203-5, HM203-6, HM204, HM204-2, HM205, HM208 and HM605	HZ46

Viewing Hood HZ47

For HM203, HM204, HM205, HM208, HM605, HM705, HM808 and HM312, HM412, HM512, HM812

Scope-Tester HZ60

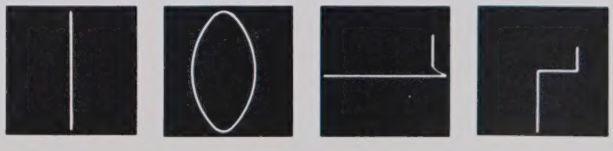
For Checking the Y amplifier, timebase, and compensation of all probes, the HZ60 is a crystal-controlled, fast rising (typ. 3ns) square-wave generator with switchable frequencies of 1, 10, 100kHz, and 1MHz. Three BNC outputs provide signals of 25mV_{pp} into 50Ω, 0.25V_{pp} and 2.5V_{pp} (open circuit for 10x and 100x probes); accuracy ±1%. Battery-powered or AC supply operated (optional).

Component-Tester HZ65

Indispensable for trouble-shooting in electronic circuits. Single component and in-circuit tests are both possible. The HZ65 operates with all scopes, which can be switched to X-Y operation (ext. horizontal deflection). Non-destructive tests can be carried out on almost all semiconductors, resistors, capacitors, and coils. Two sockets provide for quick testing of the 3 junction areas in any small power transistor. Other components are connected by using 2 banana jacks. Test leads supplied.

Examples of Test Displays:

Short circuit | Capacitor 33µF | Junction E-C | Z-Diode <8V



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General Information

The HM 208 is a combination of a normal analog (real time) oscilloscope with a digital memory oscilloscope. The button **STORAGE ON** needs to be pushed only once for to switch over from analog to digital signal processing. Internal switching from analog to digital time base takes place at the same time.

The HM 208 is easy to operate. The logical arrangement of the controls allows that anyone to become familiar with the operation of the instrument after a short time, however, experienced users are also advised to read through these instructions so that all functions understood.

Immediately after unpacking, the instrument should be checked for mechanical damage and loose parts in the interior. If there is transport damage, the supplier must be informed immediately. The instrument must then not be put into operation.

In addition, it must be determined before commissioning if the instrument is set to the correct mains voltage. Should the value marked with the arrow on the rear cover not agree with the existing mains voltage, the unit must be switched over according to the instructions on page M2.

Safety

This instrument has been designed and tested in accordance with ***IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus***, and has left the factory in a safe condition. The present instruction manual contains important information and warnings which have to be followed by the user to ensure safe operation and to retain the oscilloscope in safe condition. The case, chassis and all measuring terminals are connected to the protective earth contact of the appliance inlet. The instrument operates according to ***Safety Class I*** (three-conductor power cord with protective earthing conductor and a plug with earthing contact). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

Warning! Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption of the protective earth connection is prohibited. The mains plug shall be inserted before connections are made to measuring circuits.

The grounded accessible metal parts (case, sockets, jacks) and the mains supply contacts (line, neutral) of the instrument have been tested against insulation breakdown with 1500 V r.m.s. (50 Hz).

Under certain conditions, 50 Hz or 60 Hz hum voltages can occur in the measuring circuit due to the interconnection with other mains powered equipment or instruments. This can be avoided by using an isolation transformer (Safety Class II) between the mains outlet and the power plug of the instrument. When displaying waveforms where the "low–level" side of the signal is at a high potential, even with the use of a protective isolation transformer, it should be noted that this potential is connected to the oscilloscope's case and other accessible metal parts. High voltages are dangerous. In this case, special safety precautions are to be taken, which must be supervised by qualified personnel if the voltage is higher than 42 V.

Most cathode-ray tubes develop X-rays. However, with the HM 208, the dose equivalent rate falls far below the maximum permissible value of 36 pA/kg (0.5 mR/h).

Whenever it is likely that protection has been impaired, the instrument shall be made inoperative and be secured against any unintended operation. The protection is likely to be impaired if, for example, the instrument

- shows visible damage,
- fails to perform the intended measurements,
- has been subjected to prolonged storage under unfavourable conditions (e.g. in the open or in moist environments),
- has been subject to severe transport stress (e.g. in poor packaging).

Operating conditions

The instrument has been designed for indoor use.
The permissible ambient temperature range during operation is +10 °C ... +40 °C. It may occasionally be subjected to temperatures between +10 °C and −10 °C without degrading its safety. The rated range of use is +10 °C ... +35 °C. The permissible ambient temperature range for storage or transportation is −40 °C ... +70 °C.

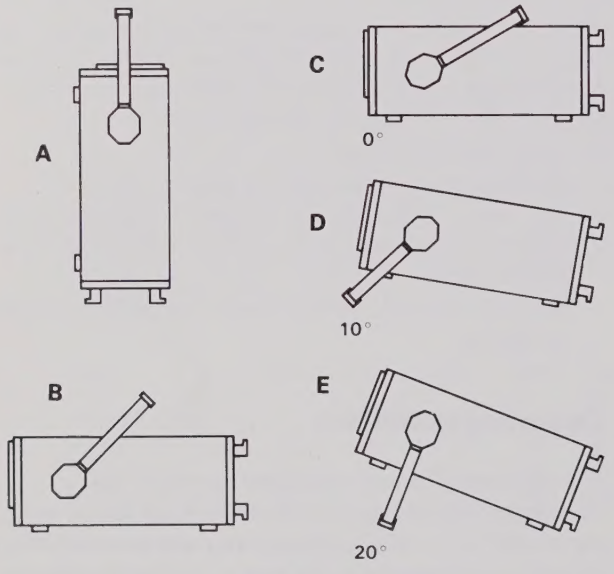
The maximum operating altitude is up to 2200 m (non-operating 15000 m). The maximum relative humidity is up to 80%.

If condensed water exists in the instrument it should be acclimatized before switching on. In some cases (e.g. extremely cold oscilloscope) two hours should be allowed before the instrument is put into operation. The instrument should be kept in a clean and dry room and must not be operated in explosive, corrosive, dusty, or moist environments. The oscilloscope can be operated in any position, but the convection cooling must not be impaired. ***The ventilation holes may not be covered***. For continuous operation the instrument should be used in the horizontal position, preferably tilted upwards, resting on the tilt handle.

Use of tilt handle

The handle of the oscilloscope can be locked in five positions, two carrying positions (Fig. A, B) and three positions for optimum screen viewing (Fig. C, D, E). If the instrument is set down vertically on the rear panel feet after carrying, the handle remains automatically in the carrying position (Fig. A). As can be seen from figure B, the handle can also be engaged in a position for horizontal carrying.

Starting with the vertical carrying position (Fig. A), the handle is pulled sideways slanting upwards (after putting the instrument down) and then engaged in the desired position with turning and following pressure. To change the position, simply pull out the handle (approx. 5mm), turn sidewards and again engage in the desired position by pressing.



Guarantee

Each instrument runs through a quality test with 10 hour burn-in before leaving the production. Practically every early failure is detected in intermittent operation by this. However, it is possible that a component fails only after a lengthy operating period. Therefore a ***functional guarantee of 2 years*** is given for all units. The condition for this is that no modifications have been made in the instrument. In the case of shipments by post, rail or carrier it is recommended that the original packing is carefully preserved. Transport damages are not covered by the guarantee.

In the case of a complaint, a label should be attached to the housing of the instrument which describes briefly the faults observed. If at the same time the name and telephone number (dialing code and telephone or direct number or department designation) is stated for possible queries, this helps towards speeding up the processing of guarantee claims. In the case of guarantee, shipments sent post unpaid are also accepted by HAMEG.

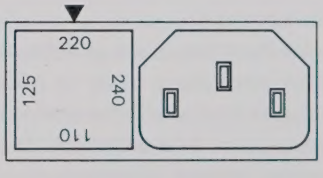
Maintenance

Various important properties of the oscilloscope should be carefully checked at certain intervals. Only in this way is it largely certain that all signals are displayed with the exactness on which the technical data are based. The test methods described in the test plan of this manual can be performed without great expenditure on measuring instruments. However, purchase of the new HAMEG scope tester HZ 60, which despite its low price is highly suitable for tasks of this type, is very much recommended.

The exterior of the oscilloscope should be cleaned regularly with a dusting brush. Dirt which is difficult to remove on the casing and handle, the plastic and aluminium parts, can be removed with a moistened cloth (water +1% relaxing agent). Spirit or washing benzine (petroleum ether) can be used to remove fatty dirt. The screen may be cleaned with water or washing benzine (but not with spirit (alcohol) or solvents), it must then be wiped with a dry clean lint-free cloth. Under no circumstances may the cleaning fluid get into the instrument. The use of other cleaning agents can attack the plastic and paint surfaces.

Switching over the mains voltage

The instrument is set for 220 V mains voltage on delivery. It can be switched over to other voltages at the fuse holder combined with the 3-pole appliance inlet at the rear of the instrument. Firstly the fuse holder printed with the voltage values is removed using a small screw driver and - if required - provided with another fuse. Refer to the table below for the prescribed value of the fuse. Then replace the fuse holder so that the impressed white triangle points to the desired mains voltage. Here pay attention that the cover plate is also correctly engaged. The use of repaired fuses or short circuiting the fuse holder is not allowed. Damages arising because of this are not covered by the guarantee.



Fuse type: Size **5 x 20 mm**; 250 V~, C;
IEC 127, Sheet III; DIN 41 662 (possibly DIN 41 571 sheet 3).
Cutoff: **Time lag** (**T**).

Subject to change without notice

Mains voltage	Fuse rating
110 V ~ ±10%	**T0.63 A**
125 V ~ ±10%	**T0.63 A**
220 V ~ ±10%	**T0.315 A**
240 V ~ ±10%	**T0.315 A**

Type of the signal voltage

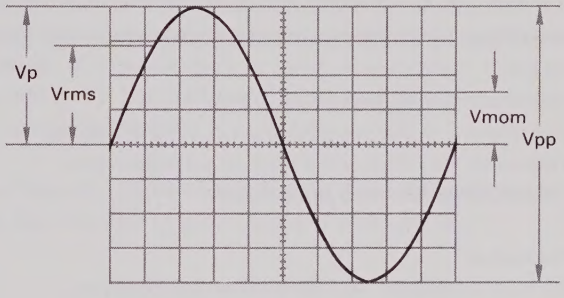
With the HM 208, practically all periodically repeating signals with the frequency spectrum below 20 MHz can be examined in the ***analog real time mode***. (Because of the limited scanning rate, other limits which are further influenced by signal shape and screen amplitude apply in the digital memory mode.) The display of simple electrical processes, such as sinusoidal RF and LF signals or mains frequency hum voltages is straightforward. When recording square-wave or pulse-type signal voltages, it must be noted that their ***harmonics*** must also be transmitted. The repetition frequency of the signal must therefore be significantly smaller than the upper limit frequency of the vertical amplifier. Accurate evaluation of such signals is only possible up to approximately 2 MHz repetition frequency. Displaying composite signals can be difficult, especially if they contain no repetive higher amplitude content which can be used for triggering. This is the case with bursts, for instance. To obtain a well-triggered display in this case, the assistance of the variable time control may be required. ***Television video signals*** are relatively easy to trigger. Nevertheless, when displaying at frame frequency, the **TRIG** selector switch must be in the **LF** position. The faster line pulses are then attenuated by a low pass filter to such an extent it is easily possible to trigger on the leading or trailing edge of the frame-synchronizing pulse using the level control.

For optional operation as a DC or AC voltage amplifier, the vertical amplifier input is provided with a **DC/AC** switch. The **DC** position should only be used with a series-connected attenuator probe or at very low frequencies or if the measurement of the DC voltage content of the signal is absolutely necessary.

When displaying very low frequency pulses, the flat tops may be sloping with **AC** coupling of the vertical amplifier (**AC** limit frequency approx. 1.6 Hz for −3dB). In this case, **DC** operation is preferred, provided the signal voltage is not superimposed on a too high DC level. Otherwise a capacitor of adequate capacitance must be connected to the input of the vertical amplifier with DC coupling. This capacitor must have a sufficiently high breakdown voltage rating. **DC** coupling is also recommended for the display of logic and pulse signals, especially if the pulse duty factor changes constantly. Otherwise the display will move upwards or downwards at each change. Pure direct voltages can only be measured with **DC**-coupling.

Size of the signal voltage

In general, AC voltage values normally refer to the rms value (root means square value). However, for signal voltages in oscilloscope measurements, the peak to peak voltage (V_{pp}) values is used. This is the potential difference between the most positive and the most negative point of a wave form. If the peak to peak value V_{pp} of a sine wave, displayed on the oscilloscope screen, is to be converted into an rms value, divide V_{pp} by $2 \times \sqrt{2} = 2.83$. Conversely multiply sine wave voltages stated in V_{rms} by 2.83 to find V_{pp}. The relationships between the different voltage values can be seen in the following diagram.



Voltage values of a sine wave
V_{rms} = root means square value; V_p = simple peak value; V_{pp} = peak to peak value; V_{mom} = momentary value.

The minimum required signal voltage at the Y-input for a 1 cm high display is approx. ***1 mV$_{pp}$***, input attenuator switch set to **5 mV/cm, *variable control knob*** turned to the right stop and ***pulled out.*** However, even smaller signals can be displayed. The voltage coefficients at the input attenuator are stated in mV_{pp}/cm or V_{pp}/cm. ***The size of the voltage applied is determined by multiplying the voltage coefficient by the vertical display height in cm***. If the X10 attenuator probe is used, multiply your coefficient by 10. ***For amplitude measurements, the variable control on the input attenuator switch must be in its calibrated position CAL.*** (arrow pointing horizontally to the right). If the fine control knob is turned to the left, the sensitivity in each attenuator switch position is reduced by a factor of at least 2.5. Thus any intermediate value inside the 1-2-5 scale can be set. ***Signals up to 400 V$_{pp}$*** can be displayed with direct connection to the Y-input (attenuator switch to **20 V/cm**, variable control to left stop). If the variable control knob is pulled out (**MAG X5**), the sensitivity in each attenuator switch position is increased by a factor of 5. A voltage coefficient of ***1 mV/cm*** is then obtained in the **5 mV/cm** attenuator switch position when the variable control knob is at the right stop. This x5 Y-magnification knob is suitable only in the **5 mV/cm** position (increased amplifier noise, reduced bandwidth, more difficult triggering).

With the terms
H = waveform height in cm
U = input voltage in V_{pp}
A = input coefficient in V/cm on the attenuator switch, the third value can be calculated from two given values:

$$U = A \cdot H \qquad H = \frac{U}{A} \qquad A = \frac{U}{H}$$

With the* MAG X5 *button pulled out, A must be divided by 5.

However, all three values are limited. They must always lie inside the following limits with the HM 208 (trigger threshold, reading accuracy):

H between 0.5 and 8 cm, where possible between 3.2 and 8 cm
U between 1 mV_{pp} and 160 V_{pp},
A between 5 mV/cm and 20 V/cm in 1-2-5 divisions
A between 1 mV/cm and 4 V/cm in 1-2-5 divisions ***(with MAG X5 knob pulled out)***.

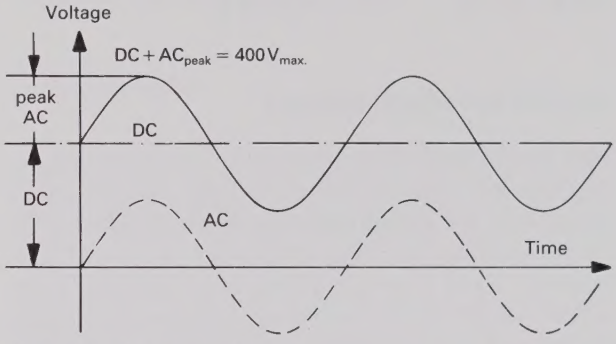
Examples:
Set input coefficient **A** = 50 mV/cm ≙ 0.05 V/cm,
signal height read off **H** = 4.6 cm
voltage sought for U = 0.05·4.6 = **0.23 V_{pp}**

Input voltage **U** = 5 V_{pp}
input coefficient set **A** = 1 V/cm
signal height sought for H = 5:1 = **5 cm**

Signal voltage U = 220 $V_{rms} \cdot 2\sqrt{2}$ = 622 V_{pp}
(voltage > 160 V_{pp}, with x10 attenuator probe, **U** = 62.2 V_{pp}), desired signal height **H** = minimum 3.2 cm, max. 8 cm
maximum input coefficient A = 62.2 : 3.2 = 19.4 V/cm
minimum input coefficient A = 62.2 : 8 = 7.8 V/cm
input coefficient to be set A = 10 V/cm.

If the measuring signal is superimposed with a direct voltage the total value (direct voltage + simple peak value of the alternating voltage) of the signal at the Y-input may not exceed ±400 V (see diagram). The same limit also applies for normal x10 attenuator probes, the attenuation of which enables signal voltages up tp approx. 1 000 V_{pp} to be evaluated. Voltages up to approx. 3 000 V_{pp} can be measured with special x100 attenuator probes (e.g. HZ 53). However, this value is reduced at higher frequencies (see technical data HZ 53). There is a risk with a normal x10 attenuator probe that such high voltages may cause the C-trimmer to break down, so that the Y-input of the oscilloscope can be damaged. However, if only the residual ripple of a high voltage is to be examined, the x10 attenuator probe is also adequate. This must then be connected in series with a correspondingly high voltage rated capacitor (around 22-68 nF).

Attention is expressly drawn to the fact that the oscilloscope input coupling must be switched to **DC** if attenuator probes are applied to voltages higher than 400 V (see "applying the signal voltage", page M6).



Total value of the input voltage
The dashed curve shows an alternating voltage which fluctuates about 0 Volt. If this voltage is superimposed on a direct voltage (DC), addition of the positive peak to the direct voltage results in the maximum voltage occurring (DC + AC peak).

With **Y-POS.** control (input coupling to **GD**) it is possible to set a horizontal graticule line as ***reference line for ground potential*** before the measurement. It can lie below or above the horizontal central line according to whether positive and/or negative deviations from the ground potential are to be measured. Certain switchable x10/x1 attenuator probes also have a built-in ground reference switch position.

Time Measurements

As a rule, most signals to be displayed are periodically repeating processes, also called periods. The number of periods per second is the repetition frequency. Depending on the time base setting of the **TIME/DIV.** switch, one or several signal periods or also only a part of a period can be displayed. The time coefficients are stated in **ms/cm** and **µs/cm** on the **TIME/DIV.**-switch. The scale is accordingly divided into two fields.
The continuous or dashed black lines traced round the scale have no significance in the ***analog mode*** of the oscilloscope. The pushbutton **TIME-ms/s** to the left of the scale also has no function in this case. It is required only in the digital memory mode.
The duration of a signal period or a part of it is determined by multiplying the time section concerned (horizontal distance in cm) by the time coefficient set on the* TIME/DIV.*-switch.
Here the variable time control (identified with a red arrow knob cap) must be in its calibrated position CAL. (arrow pointing horizontally to the right).

With the designations
L = displayed wave **length in cm** of one period,
T = **time in seconds** for one period,
F = recurrence **frequency in Hz** of the signal,

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T_c = **time coefficient in s/cm** on timebase switch and the relation **F = 1/T**, the following equations can be stated:

$$T = L \cdot T_c \qquad L = \frac{T}{T_c} \qquad T_c = \frac{T}{L}$$

$$F = \frac{1}{L \cdot T_c} \qquad L = \frac{1}{F \cdot T_c} \qquad T_c = \frac{1}{L \cdot F}$$

***With depressed* X-MAG. X10 *pushbutton the* T_c value must be divided by 10.**

However, these four values are not freely selectable. They have to be within the following limits:

L between 0.2 and 10 cm, if possible 4 to 10 cm,
T between 10 ns and 1 s,
F between 1 Hz and 20 MHz,
T_c between 200 ns/cm and 100 ms/cm in 1-2-5 sequence (with **X-MAG. X10** in out position), and
T_c between 20 ns/cm and 10 ms/cm in 1-2-5 sequence (with pushed **X-MAG. X10** pushbutton).

Examples:
Displayed wavelength **L** = 7 cm,
set time coefficient T_c = 0.5 µs/cm,
required period T = $7 \cdot 0.5 \cdot 10^{-6}$ = **3.5 µs**
required rec. freq. F = $1:(3.5 \cdot 10^{-6})$ = **286 kHz**.

Signal period **T** = 0.5 s,
set time coefficient T_c = 0.2 s/cm,
required wavelength L = 0.5 : 0.2 = **2.5 cm**.

Displayed ripple wavelength **L** = 1 cm,
set time coefficient T_c = 10 ms/cm,
required ripple freq. F = $1:(1 \cdot 10 \cdot 10^{-3})$ = **100 Hz**.

TV-line frequency **F** = 15 625 Hz,
set time coefficient T_c = 10 µs/cm,
required wavelength L = $1:(15\,625 \cdot 10^{-5})$ = **6.4 cm**.

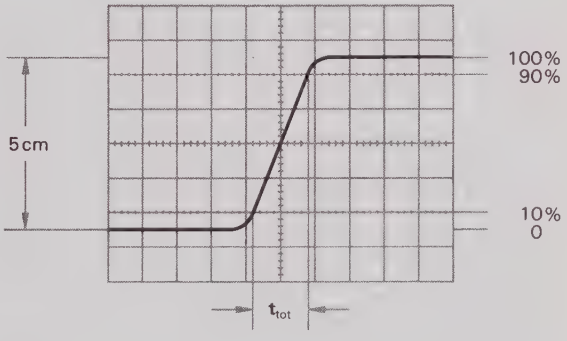
Sine wavelength **L** = min. 4 cm, max. 10 cm,
Frequency **F** = 1 kHz,
max. time coefficient $T_c = 1:(4 \cdot 10^3) = 0.25$ ms/cm,
min. time coefficient $T_c = 1:(10 \cdot 10^3) = 0.1$ ms/cm,
set time coefficient T_c = 0.2 ms/cm,
required wavelength L = $1:(10^3 \cdot 0.2 \cdot 10^{-3})$ = **5 cm**.

Displayed wavelength **L** = 0.8 cm,
set time coefficient T_c = 0.2 µs/cm,
pressed* X-MAG X10 *button: T_c = 20 ns/cm,
required rec. freq. F = $1:(4 \cdot 20 \cdot 10^{-9})$ = **12.5 MHz**,
required period T = $1:(12 \cdot 5 \cdot 10^{-6})$ = **80 ns**.

If the time is relatively short as compared with the complete signal period, an expanded time scale should always be applied (**X-MAG X10** button pressed). In this case, the ascertained time values have to be divided by ***10***.

When investigating pulse or square waveforms, the critical feature is the ***risetime of the voltage step***. To ensure that transients, ramp-offs, and bandwidth limits do not unduly influence the measuring accuracy, the risetime is generally measured between ***10%*** and ***90%*** of the vertical pulse height. For peak-to-peak signal amplitude of ***5 cm*** height, which are symmetrically adjusted to the horizontal center line, the internal graticule of the CRT has two horizontal dotted lines ±2.5 cm from the center line. Adjust the Y attenuator switch with its variable control together with the **Y-POS.** control so that the pulse height is precisely aligned with these 0 and 100 % lines. The 10 % and 90 % points of the signal will now coincide with the two lines, which have a distance of ±2 cm from the horizontal center line and an additional subdivision of 0.2 cm. ***The risetime is given by the product of the horizontal distance in cm between these two coincidence points and the time coefficient setting.*** If magnification is used, this product must be divided by 10. The ***fall time*** of a pulse can also be measured by using this method.

The following figure shows correct positioning of the oscilloscope trace for accurate risetime measurement.



With a time coefficient of 0.2 µs/cm and pushed **X-MAG X10** button the example shown in the above figure results in a measured total risetime of

$$t_{tot} = 1.6\,\text{cm} \cdot 0.2\,\mu\text{s/cm} : 5 = \mathbf{32\,ns}$$

When very fast risetimes are being measured, the risetimes of the oscilloscope amplifier and of the attenuator probe has to be deducted from the measured time value. The risetime of the signal can be calculated using the following formula.

$$t_r = \sqrt{t_{tot}^2 - t_{osc}^2 - t_p^2}$$

In this t_{tot} is the total measured risetime, t_{osc} is the risetime of the oscilloscope amplifier (approx. 17,5 ns), and t_p the risetime of the probe (e.g. = 2 ns). If t_{tot} is greater than 100 ns, then t_{tot} can be taken as the risetime of the pulse, and calculation is unnecessary.
Calculation of the example in the figure above results in a signal risetime

$$t_r = \sqrt{32^2 - 17.5^2 - 2^2} = \mathbf{26.7\,ns}$$

The measurement of the rise or fall time is not limited to the trace dimensions shown in the above diagram. It is only particularly simple in this way. In principle it is possible to measure in any display position and at any signal amplitude. It is only important that the full height of the signal edge of interest is visible in its full length at not too great steepness and that the horizontal distance at 10% and 90% of the amplitude is measured. If the edge shows rounding or overshooting, the 100% should not be related to the peak values but to the mean pulse heights. Breaks or peaks (glitches) next to the edge are also not taken into account. With very severe transient distortions, the rise and fall time measurement has little sense. For amplifiers with approximately constant group delay (therefore good pulse transmission performance) the following numerical relationship between rise time **ta** (***in ns***) and bandwidth **B** (***in MHz***) applies:

$$ta = \frac{350}{B} \qquad B = \frac{350}{ta}$$

Applying the signal voltage

Take care when applying unknown signals to the vertical input! Without an attenuator probe in series, the signal coupling switch should firstly always be at **AC** and the input attenuator switch at **20 V/cm**. If the trace is suddenly no longer visible after applying the signal voltage, it can be that the signal amplitude is much too large and totally overloads the vertical amplifier. The input attenuator switch must then be turned back to the left until the vertical deflection is only 3-8 cm high. An attenuator probe must always be connected in series at more than 160 V_{pp}. If the trace dims on applying this signal, the period of the measuring signal is probably significantly longer than the value set on the **TIME/DIV.** switch. Turn the latter to the left to a correspondingly larger time coefficient.

The signal to be displayed can be connected directly to the Y-input of the oscilloscope with a shielded test cable such as HZ 32 and HZ 34 or attenuated through a x10 or x100 attenuator probe. The use of test cables with high impedance circuits is only recommended for relatively low frequencies (up to approx. 50 kHz). For higher frequencies, the signal source must be of low impedance, i.e. adapted to the characteristic resistance of the cable (as a rule 50 Ohm). Especially when transmitting square and pulse signals, a resistor equal to the characteristic impedance of the cable must also be connected across the cable directly at the Y-input of the oscilloscope. When using a 50 Ohm cable such as the HZ 34, a 50 Ohm through termination type HZ 22 is available from HAMEG. When transmitting square signals with short rise times, transient phenomena on the edges and top of the signal may become visible if the correct termination is not used. A terminating resistance is sometimes recommended with sine signals as well. Certain amplifiers, generators or their attenuators maintain the nominal output voltage independent of frequency only if their connection cable is terminated with the prescribed resistance. Here it must be noted that the terminating resistor HZ 22 will only dissipate a maximum of 2 Watts. This power is reached with 10 V_{rms} or – at 28.3 V_{pp} with sinewave.

If a x10 or x100 attenuator probe is used, no termination is necessary. In this case, the connecting cable is matched directly to the high impedance input of the oscilloscope. When using attenuators probes, even high internal impedance sources are only slightly loaded (approx. 10 MΩ II 16 pF or 100 MΩ II 7 pF with HZ 53). Therefore, if the voltage loss due to the attenuation of the probe can be compensated by a higher amplitude setting, the probe should always be used. The series impedance of the probe provides a certain amount of protection for the vertical amplifier. Because of their separate manufacture, all attenuator probes are only partially compensated, therefore accurate compensation must be performed on the oscilloscope (see "Probe calibration" page M8).

Standard attenuator probes on the oscilloscope normally reduce its bandwidth and increase the rise time. In all cases where the oscilloscope band width must be fully utilized (e.g. for pulses with steep edges) we strongly advise using the ***modular probes HZ 51*** (x10) ***HZ 52*** (x10 HF) and ***HZ 54*** (x1 and x10) (see oscilloscope accessories, page Z1). This can save the purchase of an oscilloscope with larger bandwidth and has the advantage that defective components can be ordered from HAMEG and replaced by oneself. The probes mentioned have a HF-calibration in addition to low frequency calibration adjustment. Thus a group delay correction to the upper limit frequency of the oscilloscope is possible with the aid of the calibrator built into the HM 208 switched to 1 MHz. In fact the bandwidth and rise time of the HM 208 are not noticably changed with these probe types and the waveform reproduction fidelity can even be improved because the probe can be matched to the oscilloscope's individual pulse response.

If a x10 or x100 attenuator probe is used,* DC *input coupling must always be used at voltages above 400 V. With **AC** coupling of low frequency signals, the attenuation is no longer independent of frequency, pulses can show pulse tilts. Direct voltages are suppressed but load the oscilloscope input coupling capacitor concerned. Its voltage rating is max. 400 V (DC + peak AC). **DC**-input coupling is therefore of quite special importance with a x100 attenuation probe which usually has a voltage rating of max. 1200 V (DC + peak AC). A ***capacitor*** of corresponding capacitance and voltage rating may be connected ***in series with the attenuator*** probe input for blocking DC voltage (e.g. for hum voltage measurement).

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With all ***attenuator probes, the maximum AC input voltage*** must be ***derated*** with frequency usually above 20 kHz. Therefore the derating curve of the attenuator probe type concerned must be taken into account.

The selection of the ground point on the test object is important when displaying small signal voltages. It should always be as close as possible to the measuring point. If this is not done, serious signal distortion may result from spurious currents through the ground leads or chassis parts. The ground leads on attenuator probes are also particularly critical. They should be as short and thick as possible. When the attenuator probe is connected to a BNC-socket, a BNC-adapter, which is often supplied as probe accessory, should be used. In this way ground and matching problems are eliminated.

Hum or interference appearing in the measuring circuit (especially when a small deflection coefficient is used) is possibly caused by multiple grounding because equalizing currents can flow in the shielding of the test cables (voltage drop between the protective conductor connections, caused by external equipment connected to the mains, e.g. signal generators with interference protection capacitors).

Operation

While reading the operating instructions better fold out the front view of the unit provided at the end of the instructions.

As with all HAMEG oscilloscopes the front panel is divided up into fields corresponding to the different functions as with all HAMEG oscilloscopes. The controls for intensity (**INTENS.**), focus (**FOCUS**) and trace rotation (**TR**) are located directly beneath the screen. These are followed by the **DOT JOIN** button (for memory output), graticule illumination switch (**ILLUM.**), calibrator output (**CAL. 0.2 V** and **2 V**) with frequency selector button (**1 kHz** or **1 MHz**), 10 time magnification button (**X-MAG.X10**) and the knob for the horizontal trace position (**X-POS.** = X position).

The power switch (**POWER**) with symbols for its on- and off-position is located in the X-field at the top next to the screen. The adjustment controls for time base (**TIME/DIV.**) and triggering (**TRIG.**) are also located here.

Triggering includes the following:

- **AT/NORM**-button for switching over from automatic to normal triggering
- **LEVEL** knob for trigger level adjustment (only) with normal triggering
- **EXT**-button for switching over from internal to external triggering
- **10 : 1** button for 10-fold attenuation of an external signal-synchronous trigger voltage applied at the socket **TRIG.INP.**
- **+/−** button for selecting the trigger edge direction (slope)
- **TRIG**-coupling switch **AC-DC-HF-LF** with mains trigger position ~
- **TRIG**-lamp (lights up when triggering start).

The time coefficients are selected in the sequency 1-2-5 with the **TIME/DIV.** time base switch. Intermediate values can be set with the small concentric knob (variable). It locates in the calibration position at the right stop. At the left stop, the time coefficient set on the switch (in analog mode) is at least 2.5 times larger. If this small knob is pulled out, the oscilloscope switches over to ***X-Y***-mode. The latter applies both for analog and memory mode. The ***analog*** time base is then completely switched off; rotating the **TIME/DIV** or. **VAR.** knob can then no longer have any effect.

The other controls located in the X-field are effective only in memory mode. They are explained later on.

The vertical amplifier inputs for channel I and II (**CH.I**, **CH.II**) are located at the bottom right with their input coupling switches **DC-AC-GD**, attenuator switches **VOLTS/DIV.** and the vertical position controls (**POS. I, II** = Y-position). The four buttons in the Y-field serve for switching the operating mode of the vertical amplifiers. They are also described in more detail below.

The controls are designed so that even with incorrect operation no damage can arise. The pushbuttons engage only auxiliary functions. When starting work, pay attention that none of the buttons is pushed in. They are used according to requirements.

The HM 208 measures all signals from DC up to a frequency of at least 20 MHz (-3dB). For sine wave signals the upper limit is approx 30 MHz. However, the vertical display height on the screen is then limited to approx. 4-5 cm. The time resolution poses no problems. For example, at approx. 25 MHz and the shortest adjustable sweep time (20 ns/cm) one wave is displayed every 2 cm. The tolerance of the values displayed is only ±3% in both directions. All values to be measured can therefore be determined relatively accurately but it should be remembered that from approximately 6 MHz upwards the vertical measuring error will increase constantly with increasing frequency. This is caused by the loss of gain of the measuring amplifier. This loss is about 10 % at 12 MHz. Approximately 11 % must therefore be added to the measured voltage value at this frequency. However, as the bandwidths of the vertical amplifiers differ (normally between 20 and 25 MHz), the measured values in the upper limit ranges cannot be defined so exactly. In addition to this – as already mentioned – the dynamic range of the Y-output stage decreases above 20 MHz with increasing frequency. The vertical amplifier is designed so that the transmission performance is not influenced by inherent overshooting.

Switching on and setting up

Before switching on for the first time, the voltage set on the mains voltage selector of the HM 208 must be compared with the local mains voltage (adjustment see page M2)!

It is recommended to initially keep all the pushbuttons out and to set the 3 control knobs with arrows in their calibrated positions* CAL. *(to the right stop) and to push them in (pull-push switches). The lines on the five knob caps should point roughly vertically upwards (center of the setting range).

It is expedient to set the **TRIG.**-switch to **AC** and the **TIME/DIV.** switch to a central position.

The instrument is switched on with the red **POWER** pushbutton. The illuminated pilot light indicates the operating condition. If no trace is visible after 10 seconds heating-up time, it is possible that the **INTENS.** control is not turned up sufficiently or the time base is not running. In addition, the **POS.**-control can also be incorrectly adjusted. It must then be checked once more whether all knobs and buttons are in their correct positions according to the instructions. Special attention must be paid to the button **AT/NORM** here. Without a test signal applied, the base line is only visible if this button is not pressed in the **AT**-position (automatic triggering). If only a dot appears (Caution, danger of burning-in), the arrow knob of the **TIME/DIV.** switch is probably pulled out. It must then be pushed in. If the base line is visible, medium brightness is set by the **INTENS.** knob and optimum focus by the **FOCUS**-knob. Here the input coupling slide switch **DC-AC-GD** (**CH.I**) should be in position **GD** (ground). The input of the vertical amplifier is then short-circuited. It is thus ensured that no signals from outside can affect focusing. Signal voltages applied at the Y-input are not short-circuited in position **GD**.

To protect the CRT, work with the minimum brightness required for by the measuring task and the surrounding illumination. ***Particular care is required with a stationary dot.*** This damage the phosphor of the tube if set too bright. Switching the oscilloscope off and on at short intervals stresses the cathode of the CRT and should therefore be avoided.

Trace rotation TR

Despite Mu-metal shielding of the CRT effects of the earth's magnetic field on the horizontal trace position cannot be entirely avoided. This depends upon the direction in which the oscilloscope is set up at the work place. The horizontal trace line at the center of the screen may not align exactly parallel with the center line of the graticule. Correction of a few degrees is possible by turning a potentiometer behind an opening on the front panel marked with TR using a small screw driver.

Correction of the DC balance

After a certain time in use, it is possible that the thermal properties of the double FETs in the inputs to the two vertical amplifiers may have changed slightly. The DC balance of the amplifier is often also displaced in this case. This is detected if ***the trace position changes noticably*** when ***the small knob*** with red arrow cap at the **CH.I** or **CH.II** input attenuator ***is pulled out***. If the unit is at normal operating temperature or has been in operation for at least 20 minutes, changes below 1 mm do not require correction. Larger deviations are corrected with the aid of a small screw driver with a blade width of approx. 3 mm. The openings for this are located at the bottom of the casing (approx. 85 mm from the front edge of the casing, approximately aligned with the attenuator switches for Channel I and II. Insertion depth approx. 16 mm). The screw driver blade fits into a funnel-shaped recess so that it can be introduced without difficulty. The variable control knob is pulled out and pushed in during the correction (sweep coefficient **5 mV/cm**; input coupling on **GD**). The DC balance is correctly adjusted when the vertical trace position no longer changes with switching.

Probe calibration and use

The attenuator probe must be matched exactly to the input impedance of the vertical amplifier to ensure an undistorted display of waveforms. A switchable generator built into the HM 208 supplies a square wave signal for this purpose with very short rise time (<5 ns) at 1 kHz or 1 MHz frequency, selected by pushbutton. The square wave signal can be taken from the two concentric sockets beneath the screen. One socket supplies **0.2V_{pp}** ±1% for x10 attenuator probes, the other **2V_{pp}** ±1% for x100 attenuator probes. These voltages correspond in each case to a screen amplitude of ***4 cm*** provided the input attenuator switch of the HM 208 is set to the deflection coefficient **5 mV/cm**. The internal diameter of the sockets is 4.9 mm and corresponds directly to the (grounded) external diameter of the shielding tube of modern ***modular probes*** and probes of the ***series F*** (internationally standardized). This is the only way to produce an extremely short ground connection which is essential for high signal frequencies and an unadulterated wave form display of non-sinusoidal signals.

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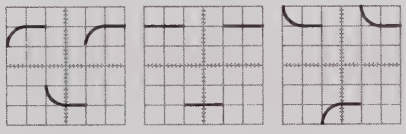
1 kHz compensation

This C-trimmer calibration compensates the capacitive loading of the oscilloscope input (approx. 30 pF for the HM 208). After calibration, the capacitive attenuation has the same attenuation ratio as the ohmic divider. The same voltage attenuation then results at high and low frequencies as for direct voltage (for x1 probes or probes switches over to x1, this compensation is neither necessary nor possible). The trace line must be parallel with the horizontal graticule lines (see "Trace rotation **TR**", page M8).

Connect attenuator probe (type HZ 51, 52, 53, 54 or also HZ 36) to the **CH.I** input, do not press any buttons or turn any knobs, set input coupling to **DC**, input attenuator to **5 mV/cm** and **TIME/DIV.** switch to **0.2 ms/cm** (both variable controls in calibration position **CAL.**), insert probe (without spring hook) into the corresponding **CAL.** socket (x10 probe in **0.2 V** socket, x100 in **2 V** socket).

1 kHz



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2 wave can be seen on the screen. The compensation trimmer must now be adjusted. It is generally located in the probe itself. It is located in the x100 attenuator probe HZ53 in the small box on the BNC plug. Adjust the trimmer with the insulating screw driver provided until the tops of the square wave signal are exactly parallel to the horizontal graticule lines (see 1 kHz diagram). The signal height should then be 4 cm ±1.2 mm (= 3 %). The signal edges are invisible during this adjustment.

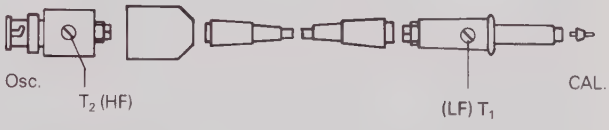
1 MHz compensation

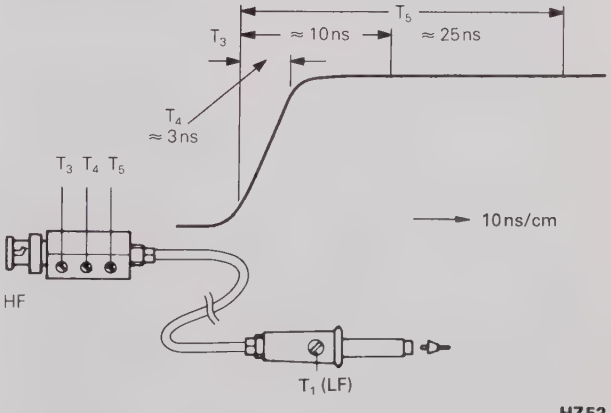
HF adjustment is possible for the HZ51, 52 and 54 probes. These possess resonance correction elements (R-trimmers in combination with coils and capacitors) with which it is possible for the first time to simply adjust the probe in the upper frequency range of the vertical amplifier. After this calibration, not only the maximum possible bandwidth is obtained in the attenuator probe mode but also a largely constant group delay at the end of the range. In this way transient distortions (such as overshooting, rounding off, ringing, holes or humps in the pulse top) in the vicinity of the leading edge are kept to a minimum. The bandwidth of the HM 208 is therefore fully utilized when using the HZ51, 52 and 54 probes without having to accept wave form distortions. Prerequisite for this HF compensation is a square wave generator with short rise time (typically 4 ns) and low-impedance output (approx. 50 Ohm) which also supplies a voltage of 0.2 V or 2 V at a frequency of 1 MHz. The calibrator output of the HM 208 fulfills these conditions when the **1 MHz** button is depressed.

Connect probes of the type HZ51, 52 or 54 to the **CH.I** input, press only **1 MHz** calibrator button and do not pull out any knobs, set input coupling to **DC**, input attenuator to **5 mV/cm** and **TIME/DIV.** switch to **0.2 µs/cm** (both fine controls in calibration position **CAL.**). Insert probe in **0.2 V** socket. The square-wave edges are now visible on the screen. The leading edge and the upper left pulse top corner should be observed. Remove the insulating cap directly behind the BNC plug of the attenuator probe (hold cap, unscrew cable strain relief union nut, withdraw insulating cap from the BNC plug, screw back union nut with cable). One slotted trimmer screw is visible with the types HZ51 and HZ54 in the box behind the BNC plug, and 3 slotted screws in the type HZ52. Adjust the upper left pulse top for optimum with these. Neither overshooting nor rounding off is allowable. This is quite simple for HZ51 and 54, but somewhat more difficult for the x10 HF probe HZ52 with 3 trimmers. In this case it is possible to adjust the leading edge steepness and to straighten out aberrations in the pulse top directly next to the leading edge. The leading edge should be as steep as possible but the top as straight as possible. HF compensation is simplified in that the 3 trimmers each possess a defined area of influence (see the following drawings). The start of the pulse top is clearly visible with the **X-MAG. X10** button depressed.

Adjusting points of the probes

HZ51, HZ54

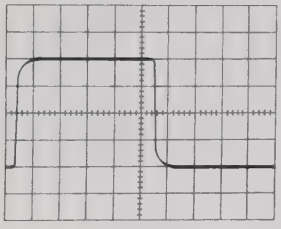




HZ52

T3: Influence on the medium frequencies
T4: Influence on the leading edge
T5: Influence on the lower frequencies

After completion of HF compensation, check the signal height on the screen at 1 MHz as well. It should have the same value as stated above for the 1 kHz compensation. Now refit the insulating cap to the BNC plug.



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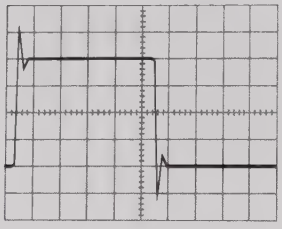

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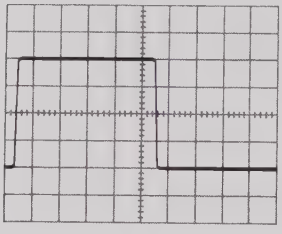

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Attentuator probes other than those mentioned above generally have larger probe diameters and do not fit into the calibrator sockets. It is not difficult for a good technician to make a suitable adapter for this. However, we would point out that such attenuator probes usually have a too long rise time so that the total bandwidth of oscilloscope with attenuator probe is far below that of the HM 208. Also these probes do not normally have compensation facilities. Therefore, wave form distortions cannot be excluded at high repetition frequencies.

It is important that the sequence of firstly 1 kHz and then 1 MHz compensation must be followed but need not be repeated, also calibrator frequencies of 1 kHz and 1 MHz cannot be used for time calibration. The pulse duty factor also deviates from the value 1 : 1. Short rise time, horizontal pulse tops, calibrated pulse height and zero potential at the pulse bottom are essential for exact attenuator probe calibration. Frequency and pulse duty factor are not critical here.

Low pulse rise time and low-impedance generator output are particularly important for assessing the transmission performance. The calibrator of the HM 208 can even replace expensive square wave generators with these properties and the switchable frequency, e.g. when calibrating wideband attenuators or in the assessment of wideband amplifiers.

The test circuit can be connected via a suitable probe from one of the HM 208 **CAL.** sockets. Plug the probe tip into the **0.2V** output socket. Select either **1 kHz** or **1 MHz** output frequency. If your circuit has a high input impedance (e.g. 1 MΩ II 15-50 pF minimum) then use an attenator probe such as x10 or x100. The applied signal will then be the **CAL.** output divided by the probe attenator e.g. 0.2 V : 10 = 20 mV etc. HAMEG probes type HZ51, 52, HZ53 and 54 are suitable for this application. However if your circuit has a low input impedance (e.g. 50 Ω), a x1 probe can be used (in this case use a 50 Ω termination). The HAMEG HZ50 and HZ54 (x1 position) probes are suitable. The latter must be switched over to x1 and its HF trimmer beneath the insulating cap of the BNC plug set to the left stop. Approx. 40 mV_{pp} are then obtained at the circuit input (at 50 Ohm) with the HZ50 and approx. 24 mV_{pp} with the HZ54 when the probe is inserted in the **0.2 V CAL.** socket. The voltage values stated here have a tolerance larger than 1 % because 50 Ohm loading is not normal for this generator. Using the **2 V CAL.** socket under the same conditions is possible only with the **HZ54**. Then approx. 190 mV_{pp} are obtained at 50 Ohm, with around twice the normal rise time. More accurate voltage values in the x1 mode can be measured immediately with the HM 208 if a 50 Ohm through connection termination **HZ22** is connected directly between the BNC plug output of the probe and the Y input of the oscilloscope.

Operating modes of the vertical amplifiers

The desired operating mode of the vertical amplifiers is selected with the 4 buttons in the Y field. All four buttons out for ***mono*** mode. Only ***Channel I*** is then operational. The button **CH I/II-TRIG.I/II** must be depressed in mono mode for ***Channel II***. The internal triggering is simultaneously switched over to Channel II with this button.

If the **DUAL** button is depressed, both channels are working. Two signals can be displayed together in this button position (alternate mode). This mode is not suitable for displaying very slow-running processes. The display then flickers too much or it appears to jump. If the **CHOP.** button is depressed in addition to **DUAL**, both channels are switched over constantly at a high frequency within a sweep period (CHOP mode). Slow running processes ***below 1 kHz*** are then also displayed without flicker. The dual mode chosen is less important for signals with higher repetition frequency.

If only the **ADD** button is depressed, the signals of both channels are ***added*** (**I + II** = sum display). If Channel I is then inverted (**INV.I** button depressed) display of the ***difference*** (**−I+II**) is also possible. The vertical position of the display depends upon the **Y-POS.** controls of both channels in these modes. The ***same attenuator switch position*** is normally used for both channels with algebraic addition.

Signal voltages between two high-potential circuit points are often measured in the ***difference mode*** of both channels. Currents between two ungrounded circuit points can also be measured as voltage drop across a known resistance. Generally when displaying different signals, both signal voltages should only be picked up with attenuator probes of absolutely the same impedance and attenuation. It is advantageous for some difference measurements ***not***

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to connect the ground cable of both attenuator probes to the object under test. Hum or common-mode interference often be reduced by this technique. Common-mode rejection can easily be above 40 dB, when ***one*** of the attenuator switch variable controls is turned a little to the left away from the calibration position. The correct knob for this must be found by trial and error.

X-Y mode

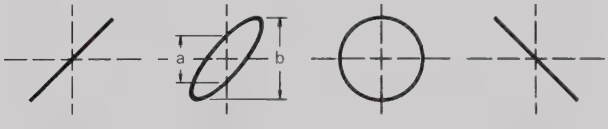
For ***X-Y mode***, the time base variable knob in the X field is pulled out (see marking at the lower edge of the time switch scale). The X signal is supplied through the input of ***Channel II. The input attenuator and variable control of Channel II are used in the X-Y mode for the amplitude adjustment in the X direction.*** However, the **X-POS.** control must be used for horizontal position adjustment. The position control of Channel II is switched off in the X-Y mode (this applies only for the ***analog mode*** of the oscilloscope). The maximum sensitivity and input impedance are now the same in both deflection directions. The **X-MAG. X10** button (beneath the screen) for expansion of the sweep should not be depressed in this case. The frequency limit in the X direction is approx. 2.5 MHz (−3 dB). However it should be noted that even above 50 kHz, a noticable phase difference between X and Y occurs and this increases with frequencies. The Y signal can be inverted with the **INV.I** button.

Lissajous figures can be displayed in the ***X-Y mode*** for certain measuring tasks:

- Comparing two signals of different frequency or bringing one frequency up to the frequency of the other signal. This also applies for whole number multiples or fractions of the one signal frequency.
- Phase comparison between two signals of the same frequency.

Phase comparison with Lissajous figure

The following diagrams show two sine signals of the same frequency and amplitude with different phase angles.



Calculation of the phase angle or the phase shift between the X and Y input voltages (after measuring the distances **a** and **b** on the screen) is quite simple with the following formula and a pocket calculator with trigonometric functions and besides ***independent of the sweep amplitudes*** on the screen.

$$\sin \varphi = \frac{a}{b}$$

$$\cos \varphi = \sqrt{1 - \left(\frac{a}{b}\right)^2}$$

$$\varphi = \text{arc sin } \frac{a}{b}$$

The following must be noted here:

- Because of the periodic nature of the trigonometric functions, the calculation should be limited to angles ≤90°. However here is the advantage of the method.
- Do not use a too high test frequency. The phase shift of the two oscilloscope amplifiers of the HM 208 in the X-Y mode can exceed an angle of 3° above 100 kHz.
- It cannot be seen as a matter of course from the screen display if the test voltage leads or lags the reference voltage. A CR network before the test voltage input of the oscilloscope can help here. The 1 MΩ input resistance can equally serve as R here, so that only a suitable capacitor C needs to be connected in series. If the aperture width of the ellipse is increased (compared with C short-circuited), then the test voltage leads the reference voltage and vice versa. This applies only in the region up to 90° phase shift. Therefore C should be sufficiently large and produce only a relatively small just observable phase shift.

Should both input voltages be missing or fail in the X-Y mode, a very bright light dot is displayed on the screen. This dot can burn into the phosphor at a too high brightness setting (INTENS. knob) which causes either a lasting loss of brightness, or in the extreme case, complete destruction of the phosphor at this point.

Phase difference measurement in DUAL mode

A larger phase difference between two input signals of the same frequency and shape can be measured very simply on the screen in Dual mode (**DUAL** button depressed). The time base should be triggered by the reference signal (phase position 0). The other signal can then have a leading or lagging phase angle. Alternate mode should be selected for frequencies ≥1 kHz; the Chop mode is more suitable for frequencies <1 kHz (less flickering). For greatest accuracy adjust not much more than one period and approximately the same height of both signals on the screen. The variable controls for amplitude and time base and the **LEVEL** knob can also be used for this adjustment – without influence on the result. Both base lines are set onto the horizontal graticule center line with the **Y-POS.** knobs before the measurement. With sinusoidal signals, observe the

zero (crossover point) transitions; the sine peaks are less accurate. If a sine signal is noticably distorted by even harmonics, or if an offset direct voltage is present, **AC** coupling is recommended for ***both*** channels. If it is a question of pulses of the same shape, read off at steep edges.

Phase difference measurement in dual mode
t = horizontal spacing of the zero transitions in cm.
T = horizontal spacing ***for one period*** in cm.

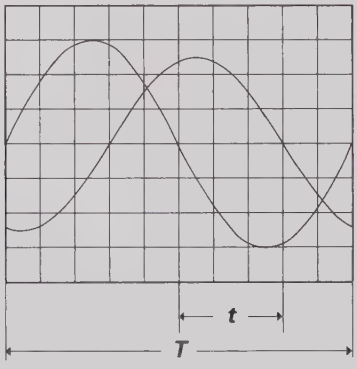
In the example illustrated, t = 3 cm and T = 10 cm. The phase difference in degrees is calculated from

$$\varphi° = \frac{t}{T} \cdot 360° = \frac{3}{10} \cdot 360° = 108°$$

or expressed in radians

$$\text{arc}\,\varphi = \frac{t}{T} \cdot 2\pi = \frac{3}{10} \cdot 2\pi = 1{,}885\,\text{rad}$$

Relatively small phase angles at not too high frequencies can be measured more accurately in the X-Y mode with Lissajous figures.



Measurement of an amplitude modulation

The momentary amplitude u at time t of a HF-carrier voltage, which is amplitude modulated without distortion by a sinusoidal AF voltage, is in accordance with the equation

$$u = U_T \cdot \sin\Omega t + 0{,}5m \cdot U_T \cdot \cos(\Omega-\omega)t - 0{,}5m \cdot U_T \cdot \cos(\Omega+\omega)t$$

where U_T = unmodulated carrier amplitude
$\Omega = 2\pi F$ = angular carrier frequency
$\omega = 2\pi f$ = modulation angular frequency
m = modulation factor ($\leqq 1 \triangleq 100\,\%$).

The lower side frequency $F-f$ and the upper side frequency $F+f$ arise because of the modulation apart from the carrier frequency F.

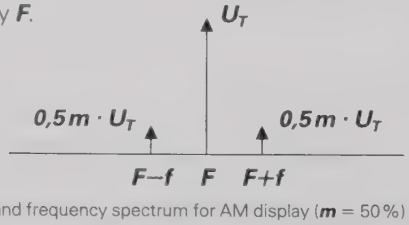


Figure 1
Amplitude and frequency spectrum for AM display (m = 50 %)

The display of the amplitude-modulated HF oscillation can be evaluated with the oscilloscope in the analog mode provided the frequency spectrum is inside the oscilloscope bandwidth. The time base is set so that several wave of the modulation frequency are visible. Strictly speaking, triggering should be external with modulation frequency (from the AF generator or a demodulator). However, internal triggering is frequently possible with normal triggering (**AT-NORM.** button depressed) using a suitable **LEVEL** setting and possibly also using the time variable adjustment.

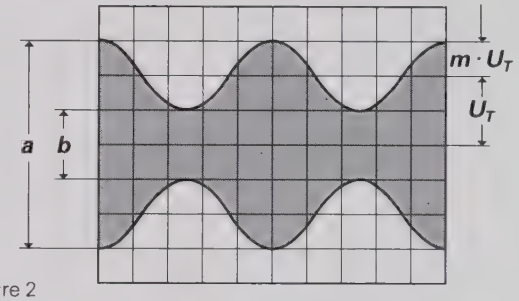


Figure 2
Amplitude modulated oscillation: F = 1 MHz; f = 1 kHz; m = 50 %; U_T = 28.3 mV_{rms}.

Oscilloscope setting for a signal according to figure 2:
Depress no buttons. ***Y***: **CH. I**; **20 mV/cm**; **AC**.
TIME/DIV.: **0.2 ms/cm**.
Triggering: **NORMAL** with **LEVEL**-setting; ***internal (or external) triggering.***

If the two values a and b are read from the screen, the modulation factor is calculated from

$$m = \frac{a-b}{a+b} \quad \text{bzw.} \quad m = \frac{a-b}{a+b} \cdot 100\,[\%]$$

where $a = U_T(1+m)$ and $b = U_T(1-m)$.

The variable controls for amplitude and time can be set arbitrarily in the modulation factor measurement. Their position does not influence the result.

Triggering and time base

A signal can be displayed only if the time base is running or triggered. To produce a stationary display, triggering must be synchronous with the test signal. This is possible by using the test signal itself or by an externally supplied but synchronous signal voltage. If the **AT/NORM.** button is not depressed, a base line is always displayed even without a signal applied. This triggering mode is therefore called ***automatic triggering***. Practically all uncomplicated periodically repeating signals above 30 Hz repetition frequency can be displayed with the **AT/NORM.** button not depressed. All that is required for operation of the time base is then just the time setting. A **LEVEL** adjustment is neither necessary nor possible with automatic triggering.

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Automatic triggering can be used both with internal and external (via the socket **TRIG.INP.**).

With ***normal triggering***, (**AT/NORM.** button depressed) and **LEVEL** setting, triggering of the time base can take place at any point on a signal edge. The triggering range covered with the **LEVEL** control is highly dependent on the amplitude of the signal displayed. If it is smaller than 1 cm, the adjustment requires some sensitivity because of the small lock-in range. With the **+/−** button not depressed, triggering starts at a positive and therefore rising edge. Should the display of a signal start with a negative and therefore falling edge, the **+/−** button must be depressed. The selection of the edge direction refers to the input signal. It is independent of the position of the **INV.I** button. Correct edge selection is particularly important if only a part of a signal period or a video signal is to be displayed.

In the case of internal triggering in the modes Channel I or II, channels I and II (**DUAL**), algebraic addition (**ADD**), the trigger signal can be taken from the channel selected with the button **CH I/II-TRIG.I/II** (in the Y section).

The **EXT.** trigger button must be depressed for ***external triggering*** and the signal (0.3 V_{pp} to 3 V_{pp}) must be supplied to the socket **TRIG.INP.**

If the adjacent **10 : 1** button is depressed as well, the external trigger voltage range is increased from 3 V_{pp} to 30 V_{pp}. However, ***a value of 100 V_{pp} should not be exceeded at the socket* TRIG.INP. *for safety reasons.*** The input impedance of this socket is 1 MΩ II 30 pF, so that an attenuator probe can also be used.

If the external trigger voltage available is smaller than 0.3 V_{pp} or larger than 30 V_{pp}, the ***external*** trigger signal can also be supplied via Channel II (**CH.I/II-TRIG.I/II** button depressed). Simply depress the **DUAL** button and set the attenuator switch of the now displayed Channel II signal to an amplitude of around 2 cm. In general it is then possible to shift this Channel II signal from the screen upwards or downwards with the **Y-POS.II** knob, so that in fact only the signal of Channel I remains visible. In this case ***normal triggering*** (**AT/NORM.** button depressed) should be used. With the variable control knob of the attenuator switch of Channel II pulled out, stable "external" triggering with 2 mV_{pp} trigger voltage at 20 MHz can be achieved. Naturally this method can be used with the channels exchanged accordingly. However, external triggering should be used only if internal triggering is not possible (e.g. with signals with extreme noise or hum or certain composite signals).

The ***coupling mode*** and the resulting frequency range of the trigger signal can be switched over both internally and externally with the **TRIG.** trigger selector switch. In the positions **AC** or **DC**, small signals (<2 cm) are triggered only up to around 10 MHz. Switch over to the **HF** position for higher signal frequencies (10-40 MHz). In principle, the instrument triggers in the positions **AC** and **DC** even at frequencies above 10 MHz; however, the trigger threshold is then increased. In the range up to 10 MHz double triggering resulting from amplifier noise is largely avoided even at the highest sensitivity of the measuring amplifier. The lower limit frequency with **AC** triggering is around 20 Hz. In the **LF** position (low frequency) frequencies above 1 kHz in the internal and external trigger signal are increasingly attenuated, high frequency disturbances and noise are therefore suppressed. The values stated above and the trigger thresholds (internal 5 mm; external 0.3 V_{pp}) apply for sinusoidal signals. The limit frequencies depend upon the signal height adjusted with internal triggering.

DC triggering is recommended only if the display is to be triggered with quite slow processes or if pulse signals with constantly changing pulse duty factors have to be displayed. ***Always work with normal triggering and level adjustment with internal DC triggering.*** Otherwise there is a possibility in the **AT** position (automatic triggering) that the triggering point may change or that triggering may not occur at all with signals without zero transition.

If the ***video signal of a television receiver is to be displayed at frame frequency,*** set the trigger selector switch in the **LF** position (low frequency) to attenuate the line pulses.

On the other hand, a ***video signal at line frequency*** can be displayed with **AC** (possibly also **DC**) trigger coupling. Pay special attention to the correct position of the **+/−** button both with frame and line frequency.

As already described, simple signals can be triggered automatically in the **AT** position even though the repetition frequency may fluctuate. However, if the pulse duty factor of a squarewave signal changes so much that one part of the squarewave reduces to a needle pulse, switching over to ***normal triggering*** and using the **LEVEL** control can be necessary. With ***composite signals***, triggering depends upon periodically repeating **LEVEL** values. Careful adjustment to these values is required using **LEVEL** control.

If no stable trigger point is found with normal triggering with extremely complex composite signals even after slowly rotating the **LEVEL** knob, solid trigger can be obtained in many cases by operating the variable time control knob on the time switch.

A (split) secondary winding voltage of the mains transformer is used as mains frequency trigger signal (50-60 Hz) for ***mains/line triggering*** in the ~ position of the **TRIG.** switch. This trigger mode depends upon the amplitude and frequency of the Y signal and is recommended for all signals synchronous to the mains. This also applies – within certain limits – to whole number multiples or fractions of the line frequency. Line trigger can also be useful to display signals below the trigger threshold (less than 5 mm). It is therefore particularly suitable for measuring small hum voltages of mains rectifiers or stray low frequency pickup in a circuit.

Single sweep (by depressing the button **SINGLE** and **RESET** in the memory section) is only possible in the ***memory mode*** of the HM 208.

As already described, in the analog real time mode of the HM 208, all numerical values printed on the time switch scale can also be set for the time coefficients. The continuous or dashed black lines surrounding the scale and the **TIME ms/s** button are of significance only in the memory mode. All time coefficients which can be set by the **TIME/DIV.** switch refer to the right stop position of its variable control knob (**CAL.**) and a base line length of 10 cm. With the time axis expanded 10-fold (**X-MAG. X10** button depressed), a maximum resolution of approx. 20 ns/cm then results (in the **0.2 µs/cm** position of the **TIME/DIV.** switch). Naturally the 10-fold X expansion can be used in any time range, but the display brightness is reduced (restore using **INTENS.** control).

Trigger indication

Both in automatic and normal triggering, the triggered condition of the time base is indicated by the LED above the **TRIG.** switch. This simplifies sensitive **LEVEL** adjustment especially for very low frequency signals. The trigger LED stays lit for approximately 100 ms for each trigger pulse detected. Thus for fast signals the LED appears to glow continuously, for low repetition rate signals, the LED flashes at the repetition rate (of the trigger point) of the input signal.

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General Information

The controls for the memory mode are nearly all located in the X section contained within boundar lines on the front panel:

The **STORAGE ON** pushbutton switches the oscilloscope from real time to memory mode. Further pressure releases the button and switches back to real time mode. ***Stored*** signals (in **HOLD** condition) are retained in the real time mode; they can be displayed on the screen at any time by pushing this button. A time coefficient changed in the meantime has no effect on the stored signals in **HOLD** condition.

STORAGE ON *LED:* This lamp indicates by shining continuously that the memory mode is switched on. It also indicates by flashing if the digital time range switch is incorrectly set (out of range). If the **TIME ms/s** button is out (ms) this occur if a time coefficient is selected outside the range enclosed by the continuous black line. If the **TIME ms/s** button is depressed (s), the valid range is that enclosed by the dashed line.

HOLD I and **HOLD II** pushbuttons serve for holding the memory contents of each channel. If they are depressed, the memory contents are retained until the mains voltage is switched off or fails. New storage is only possible on each channel when the relevant button is released (out).

2. STOR. pushbutton: If it is depressed, the unit is switched to the second memory. In this way, two different signals can be stored in each channel independent of one another and called up and compared with the two signals stored in memory 1. Releasing the **2. STOR.** button (out) reverts to the 1. stor. mode.

SINGLE pushbutton: It switches the memory timebase from repetitive sweep to single sweep. Thus single events (such as switching on or off processes, non-periodic signals) can be displayed and stored as long as required with constantly uniform screen intensity. The single sweep mode is not applicable in analogue oscilloscope operation.

RESET pushbutton: brings the memory timebase into the ready position for single sweep with the single button depressed. A suitable trigger edge arriving after operation of the pushbutton initiates the single sweep. In addition, this knob can be used to terminate the plotter writing process before the complete memory contents are written.

RESET *LED:* This lamp indicates memory readiness for single sweep mode. It goes out on triggering.

PRE-TRIG. switch with 5 positions (**0-25-50-75-100**): The start of the memory timebase can be advanced by a variable percentage of the timebase setting. If 50 % is set for example, the trigger point will be in the center of the screen. Thus display of the waveform ***before*** the trigger event is possible.

TIME/DIV. rotary switch: When the memory mode is switched on, the analog timebase is switched off. It is replaced by the digitally generated quartz control timebase. The timebase fine control knob is then out of operation. Because the digital scanning rate is limited to maximum 20 MHz, the smallest adjustable time coefficient is 10 µs/cm, the largest 50 ms/cm. These ranges are framed in black on the **TIME/DIV.** scale. However, in the memory mode much larger time coefficients are required to overcome the flickering or creeping of a light dot at very low signal frequency (unavoidable in real time mode). All coefficients on the scale bounded by a black dashed line can be extended 1 000-fold with the **TIME ms/s** button next to the timebase switch. Time coefficients between **10 µs/cm** and **50 s/cm** can thus be obtained in the memory mode.

X-Y Mode: If the time switch fine control knob is pulled out, the HM 208 switches over to X-Y memory mode. This is marked on the lower edge of the **TIME/DIV.** scale.

PLOTI and **PLOTII** pushbuttons: These controls start and control an XY (or possibly YT) plotter to plot out the channel contents of the memories. This is interfaced via a 5 pole DIN rear panel socket. Any waveform to be plotted must be first retained by depressing the **HOLD** button. The contents of channel 1 or channel 2 can be plotted by depressing **PLOTI** or **PLOTII** respectively. Should the waveform held in store 1 and store 2 need to be plotted, take care not to release the **HOLD** buttons when using the **2. STOR.** button. When the appropriate plot button is depressed, the plotter feed is switched on, the stylus lowered with a short delay and memory contents plotted out. Whilst plotting, the instantaneous plot position is indicated as a dot on the screen. When the complete memory contents are written, the stylus is lifted (penlift command), and the complete waveform can again be seen on the screen. The writing (or read out) speed can be adjusted by an internal switch in the HM208. The switch provides 10-20-40 s/cm settings in the single channel mode or 5-10-20 s/cm in the dual mode. The switch should be set to match the plotter requirements. The plotter drive voltages are 0.1 V/cm plus or minus 10 percent in both X and Y axes. A YT type plotter can be used, utilising its own X feed, although this is obviously not possible for XY plots from the oscilloscope. As previously described, the **RESET** button can be used to prematurely terminate the plot cycle.

DOT JOIN pushbutton: This button is located in the section beneath the screen, adjacent to the focus knob. Its purpose is to join a stored sequence of points by bright lines. The signal shape can often be improved by use of this control. This applies particularly with relatively large dot spacings in the vertical direction (square wave edges) or when displaying many sine wave cycles. It should be noted that slight distortion of the signal shape, especially of non-sinusoidal signals is unavoidable when this button is depressed. This appears as rounding off of the corners which follow a (rising or falling) edge. This button should therefore be depressed only when required.

Vertical resolution
Dot density in each operating mode 8 bit = 2^8 = 256 dots on 9 cm display height (28 dots per cm). However only 8 cm can be evaluated in the screen graticule.

Horizontal resolution in timebase mode
Channel I alone: Dot density 11 bit = 2^{11} = 2048 dots on 10 cm display width (200 dots per cm).

Channel II alone: Dot density 10 bit = 2^{10} = 1024 dots on 10 cm display width (100 dots per cm).

Channel I and II (**DUAL** button depressed): Dot density 10 bit = 2^{10} = 1024 dots on 10 cm display width (100 dots per cm).

Sum and difference CHII ± CHI (**ADD** button without/with **INV.I**) Dot density 11 bit = 2^{11} = 2048 dots on 10 cm display width (200 dots per cm).

Horizontal resolution in X-Y mode
Dot density horizontal (as vertical) 8 bit = 2^8 = 256 dots on 9 cm display width (28 dots per cm). Only 8 cm can be evaluated in the screen graticule on both directions.

Maximum signal frequency in memory mode
The highest frequency which can be evaluated depends upon resolution, display height adjusted, signal shape and possible use of the **X-MAG.X10** and **DOT JOIN** buttons. It cannot be strictly defined and must be assessed according to application. The denser the dot sequence which simulates the signal shape, the more accurately the memory display can be evaluated. With sine shapes the zero-axis crossings are therefore critical and with the square waves, steep edges. In the vertical direction a large (display height) setting is favourable for accurate amplitude measurement, but not for waveform assessment, because the dot density is then small. A too small display height is again inaccurate, because scanning in the X and Y direction can fluctuate by ±1 dot (statistical scatter). A 1 MHz signal in sine or symmetrical square wave shape is indeed certainly detectable with the **X-MAG.X10** and **DOT JOIN** buttons depressed, but can be evaluated at the most in its amplitude. Details such as harmonic distortion factor or edge steepness and interference pulse spikes or glitches cannot be assessed any longer with accuracy.

In principle, the HM 208 can work in digital memory mode with the same operating modes as in analog/real time mode. The following can therefore be displayed:

- channel I single
- channel II single
- channels I and II simultaneously
- sum of the channels II + I
- difference of the channels II − I
- XY mode (X = channel II, Y = channel I).

Deviations of the memory mode from the real time mode are:
- with the **DUAL** button depressed (simultaneous signal display of both channels) the facility for Chop mode does not exist. It is superfluous since the stored image does not flicker even at low frequencies. The two channels are scanned separately – but simultaneously –. However, they are read out from the two single memories after one another (alternately) and displayed on the screen. Pressing the **CHOP.** button has no effect.
- The X sweep is limited to max. 9 cm in the ***X-Y mode***. Symmetrical signal display on the screen (without clipping on one side) necessitates correct X position adjustment with the **X-POS.** and **Y-POS.II** knobs.

However, there are still further display modes in the memory mode:

- ***Refresh*** (periodical refreshing = repeated signal scanning and storage),
- ***Single*** (triggered single sweep)
- ***Pre-trigger*** (displaying ***before*** and ***after*** the signal trigger edge),
- ***Roll*** ("rolling" in particular aperiodic signals)
- ***Plotter*** (signal recording with external waveform plotter).

All operating and stored display modes with storage are dealt with in more detail in the following sections.

Single channel display

Y-section: Do not depress any buttons, select input coupling **AC** or **DC** according to signal frequency, apply signal to **CH.I**-BNC socket, select display height desired with the **VOLTS/DIV.** input attenuator switch. Fine control knob in the **CAL.** position (right stop); if required, pull out fine control knob for amplitude coefficient ***1 mV/cm*** (attenuator switch to **5 mV/cm**), adjust vertical display position with **Y-POS.I** knob.

Section beneath the screen: Adjust suitable intensity and focus with **INTENS.** and **FOCUS** knobs, do not depress any buttons, set trace line symmetrical to the graticule with **X-POS.** knob.

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X section: Depress **STORAGE ON** button (storage lamp lights up). Triggering: initially do not depress **AT/NORM.** button, select trigger coupling appropriate to signal repetition frequency. Select normal triggering for frequencies below 30 Hz (depress **AT/NORM.** button, set **DC** or **LF** on the **TRIG.** selector switch, adjust **LEVEL** knob so that **TRIG.** lamp lights up or flashes after each signal period with very low frequencies). Select trigger edge direction with **+/−** button.

Timebase: Select time coefficients on the **TIME/DIV.** switch, however remain within the black framed scale region with signal repetition frequency above around 2 Hz, with frequencies below 2 Hz depress the **TIME ms/s** button and set within the region framed by the dashed line. Set **PRE-TRIG.** switch to **0 %**, do not depress any further buttons apart from **STORAGE ON** in the storage section.

The signal is visible on the screen in this setting in the ***refresh mode***. This means that the signal is constantly rescanned and read out again from the memory. If the signal amplitude, waveform, frequency or time coefficient changes, this change is visible on the screen without any great time loss. If the **HOLD I** button is now depressed, the signal displayed at the moment of depressing is "frozen" and therefore permanently stored. In order to avoid the effect of the **DUAL** button, the **HOLD II** button should also be depressed. When the **HOLD I** button is depressed, the stored signal can no longer be influeced by any control of the oscilloscope. However, the visible signal on the screen can be expanded by pressing the **X-MAG.X10** button and shifted horizontally with the **X-POS.** knob. The **DOT JOIN** button can also be used. The maximum scanning rate is 20 MHz, the dot density 2000 dots on 10 cm display width.

The same procedure applies for ***ChannelII single channel display*** and storage. Naturally the **CHI/II-TRIG.I/II** button in the Y section must be depressed. The **HOLD II** button then serves for "freezing" the stored signal. As already stated, the dot density with Channel II only is halved.

Instead of the refresh mode, ***single sweep*** can also be selected by depressing the **SINGLE** and **RESET** buttons without any disadvantage. The scanning, storage and read out process can be repeated immediately by renewed depressing of the **RESET** button. However, if the corresponding **HOLD** button is depressed in addition, the last visible signal is permanently stored. Single sweep is recommended in particular for aperiodic signals or single events, such as a switching on process. Here the **RESET** lamp goes out when the signal starts to be scanned by triggering. The correct triggering setting (type, coupling, edge direction, level) is especially important in the case of single sweep, since without triggering the last stored signal remains unchanged in the memory and therefore is also displayed unchanged. Setting triggering with the aid of a simulated signal is recommended under certain circumstances. ***Storage with single sweep is not possible in the rolling and XY modes but in all other modes.*** It is possible to work with automatic triggering here. However, ***normal triggering*** with suitable **LEVEL** adjustment is more favourable because the trigger point on the signal is determined in this case. Premature triggering by interference pulses with zero-axis crossing can also be prevented in this way.

Memory switchover

Using the built in second memory, which is switched on by depressing the **2. STOR.** button, two stored signal images can be compared with one another. The highest resolution and simplest operation is obtained if the two signals are read into the memory consecutively through ***Channel I***.

- Depress **HOLD II** button.
- **2. STOR.** and **HOLD I** buttons must be released, in the out position
- Conclude storage of the first signal by depressing the **HOLD I** button
- Depress **2. STOR.** button
- Release **HOLD I** button
- Adjust and read-in second signal
- Depress **HOLD I** button.

Both signal images are now stored and can be called up consecutively by releasing and depressing the **2. STOR.** button. Where necessary, different time coefficients, amplitudes, Y positions and trigger settings (also single sweep) are certainly possible when reading in. The waveforms displayed at the instant of depressing the **HOLD I** button appear on recall. These images can subsequently only be varied with **DOT JOIN**, **X-MAG.X10** and **X-POS.** which, however, does not change the information in the two memories. Nevertheless, the **CHI/II - TRIG.I/II** and **DUAL** in the Y section should not be depressed when reading in and out; they must always be out. Otherwise the full resolution in the horizontal direction is not obtained. The **HOLD I** and **II** should not be inadvertently released.

Two stored signal images can also be compared with one another ***using Channel II as well***. If it is necessary to employ the full dot density of Channel I alone, ***two buttons*** (**2. STOR.** and **CH I/II-TRIG.I/II**) must be ***depressed in a certain sequence*** on reading out. This results from circuit engineering reasons (minimum expenditure, few controls).

- The **2. STOR,**, **HOLD I** and **HOLD II** and **DOT JOIN** buttons must be released, therefore out.
- Feed in and adjust first signal through Channel I.
- Conclude storage of the first signal by depressing the **HOLD I** button.
- Depress **2. STOR.** button and connect second signal to Channel II.
- Depress **CH I/II-TRIG.I/II** button.
- Change settings if necessary (triggering, time coefficient etc.)
- When the second signal image has been adjusted, depress **HOLD II** button.
- To switch over to the stored first signal image, firstly release **2. STOR.** button and then **CH I/II-TRIG.I/II** button.
- To switch over to the stored second image firstly depress **CH I/II-TRIG.I/II** button and then the **2. STOR.** button.

An incorrect sequence when reading out from the memories has the effect in the display of Channel I that only half the information (dot density) is reproduced. And in Channel II it results that half the information from Channel I is interleaved with that of Channel II (as with dual display) or – with the **DOT JOIN** button depressed – that a HF oscillation appears to overlap the display. However, the incorrect sequence does not lead to a change in the memory contents!

It is important to maintain the same position of the* CH I/II-TRIG.I/II *button when reading out from the memories as when reading in. It is unimportant, on the other hand, if the first or second memory is used for channel I. Both memories are identical. The above arrangement (**2. STOR.** button depressed = Channel II = button **CH I/II-TRIG.I/II** button depressed) is easier to remember.

If the full horizontal resolution of Channel I is not important, then leave the **CHI/II-TRIG.I/II** button in the depressed position and switch the stored image over only with the **2. STOR.** button. The position of the **DOT JOIN** button is immaterial.

Two stored waveforms can also be displayed simultaneously (above one another). For this purpose, select with the **2. STOR.** button the memory into which the image of Channel II was read, then depress the **DUAL** button. The position of the **CH I/II-TRIG.I/II** button is unimportant here.

Naturally a stored picture can also be compared with a real time picture. Usually the analog and digital time coefficients (when reading into the memory) must agree. However, exceptions to this are possible. Since the real time mode has priority in this case (its control adjustments are determined), the memory images must be read in ***beforehand***. Thus even 3 pictures can be displayed consecutively by switching over with the **STORAGE ON** and **2. STOR.** buttons.

Stored waveforms from different operating modes can also be displayed for demonstration purposes. If a stored X-Y mode image is present, the fine time control knob must also be pulled out or pushed in with the memory switchover. If single display of Channel II or DUAL display (see further below) is present, the **CH I/II-TRIG.I/II** or **DUAL** button respectively must be depressed on reading out.

Dual display

The **DUAL** button is depressed for ***dual display***. The two channels are scanned separately but quasi simultaneously (with 180° phase shift). The dot density is the same for both channels. (1000 dots on 10 cm display width each; maximum scanning rate 10 MHz.) Triggering can be internally from Channel I or from Channel II with the aid of the **CH I/II - TRIG. I/II** button. Depress both **HOLD I** and **HOLD II** buttons to freeze both signals. ***The chop mode is not effective in the memory mode.*** When the **DUAL** button is depressed the **CHOP** button has no effect. As in the real time mode, the phase difference of two synchronous signals of the same frequency and shape can be measured on the screen (see page M12). The **INV.I** button may not be depressed here. ***Both*** the input coupling switches must be set to **DC** or ***both*** to **AC**.

Sum and difference display

The ***sum of two signals*** is stored and displayed with the **ADD** button depressed and the **DUAL** and **INV.I** buttons ***not depressed***. Internal triggering from Channel I or Channel II with the aid of the **CH I/II-TRIG.I/II** button is also possible here. The dot density is high (max. scanning rate 20 MHz; 2000 dots on 10 cm). The **HOLD I** button should be used for freezing the memory contents.

The ***difference between two signals*** appears if both the **ADD** and **INV.I** buttons are depressed. The **DUAL** button must remain released (out). Dot density and internal triggering are as already described for the sum. The memory contents are also frozen with the **HOLD I** button in the case of difference formation.

With (stored) sum and difference measurement, the display can be shifted vertically with both **Y-POS.I** and **Y-POS.II** knobs. The two signals must generally be synchronous, but they may certainly have a constant phase difference. If they are not synchronous (beat) then the display "breathes" in the refresh mode. This means that "freezing" by depressing the **HOLD I** button or in single sweep with the **SINGLE** and **RESET** buttons shows an amplitude curve which

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depends upon the (random) instant of depressing these buttons. Thus an apparent damped oscillation can result, for instance. Nevertheless, the envelope follows neither a sine nor an e function. It can be regarded as a multiple modulated oscillation.

Reference line display

Sometimes the need arises to ***delete the memory contents*** and to ***display*** only one or – in dual mode – ***both base lines*** and to line them up to a horizontal graticule line. Automatic triggering is required for this (***do not depress*** **AT/NORM., SINGLE, HOLD** and **TIME ms/s** buttons). In addition, the input coupling switch or switches are set to **GD**. The base line can now be varied appropriately vertically with **Y-POS.I** and **Y-POS.II**. Applied signals have no effect in this case.

Timebase of low frequency signals

In the memory mode, the scale ranges of the **TIME/DIV.** switch ***framed by a dashed*** line are slowed down by a factor of 1000 with the aid of the **TIME ms/s** button. If the **TIME ms/s** button is depressed, 0.1 s up to 50 s/cm are therefore read on the scale (instead of 0.1 ms/cm to 50 ms/cm). If exactly one signal period is to be displayed over 10 cm screen width, a frequency range of 2 mHz to 1 Hz results. If 1 signal period per cm is displayed, the frequency range is 20 mHz to 10 Hz. However, there are some special features with the **TIME ms/cm** button depressed.

Triggering: It is certainly self-evident that the input coupling for the signal input or inputs must be set to **DC** for low frequency signals. But this also applies for the trigger coupling switch in the X section. This must be set either to **DC** or to **LF**. If it is set to **LF**, noise and interference frequencies which could possibly cause premature triggering are suppressed above 1 kHz (low pass filter), but the low frequency signal components – including DC – are transmitted. Normal triggering should be used (**AT/NORM** button depressed), because automatic triggering cannot be used below 30 Hz. However, (the **AT** position is used for the rolling mode described further below) provided the **LEVEL** knob is correctly adjusted, a display as in the refresh mode results: The signal waveform is constantly rewritten.

Trigger lamp: With low frequency signals (below approx. 10 Hz) the trigger lamp lights up only in flashes, each time when the set trigger point on the signal waveform is run through. For example, if 3 periods of the signal are displayed on the screen, the trigger lamp lights up three times. But only the first flash initiates the timebase. Triggering is blocked at the two other flashes until advance (and return) of the saw-tooth period is completed. Multiple flashing also applies with single sweep except the timebase stops after the single advance.

Single sweep: The single timebase operates with the **SINGLE** and **RESET** buttons depressed. It depends upon the measurement task as to when single sweep mode is required. The **RESET** ***lamp*** shows readiness for triggering. It goes out at the instant of triggering. If the **RESET** button is depressed whilst the time sweep is running, the lamp lights up immediately. The current time sweep is interrupted. Scanning and storage start at this instant. The **RESET** ***lamp*** goes out if the trigger signal runs through the set trigger point. If the chosen time coefficient in the extreme case is 50 s/cm, the waiting time lasts for 500 s. The previously stored waveform is retained during the waiting time. In return, however, the read out, visible image appears immediately after the single sweep ends. This also applies for the dual display, for both channels are scanned, stored and read out almost simultaneously. Apart from the X-Y display, single sweep and rolling mode can be used in all operating modes.

Rolling mode: Rolling mode is obtained if the **TIME ms/s** is depressed but the **AT/NORM** button is not depressed. Naturally the **SINGLE** button must also not be depressed here. The wave train of a signal travels from the ***right*** display margin to the ***left*** display margin in the rolling mode. Each change in the signal appears at the right display edge and runs across to the left display margin. The display can be held and permanently stored with the **HOLD I** button – if the point of interest has travelled up to the screen center, for instance. A particular pulse group (e.g. a double pulse) or glitch can also be sought out from an aperiodical pulse sequence, stored and examined. The "travelling" speed on the screen changes with the time coefficient in the range of the **TIME/DIV.** switch framed by the dashed line. Since triggering is switched off in the rolling mode, there is no need to bother about trigger threshold, trigger coupling, edge direction etc. The time coefficient can be changed within a large range as required.

Pre-triggering

The course of the signal can be followed in particular before (and possibly also after) the set trigger point with pre-triggering. The **PRE-TRIG.** switch shows the values **0-25-50-75-100**. These are ***percentages*** which refer to the horizontal screen width of 100 mm, counting from left to right. At the 75 % value, the trigger point therefore is 75 mm to the right of the left graticule edge. The 100 % value lies on the

right graticule edge. The trigger point itself can be set arbitrarily with the **LEVEL** knob (and the **+/−** button) (e.g. in the zero-axis crossing or edge center or in the peak of a sine wave) with normal triggering switched on (**AT/NORM** button depressed). This setting occurs generally if the **PRE-TRIG.** switch is set to **0**. If this switch is now set to **50**, then the same trigger point now lies in the center of the screen. The "case history" of the signal before (and after) the trigger point is now visible. With suitable timebase setting, critical points can also be followed over a lengthy period by setting a larger number of signal periods on the screen.

It is also possible to use pre-triggering with ***single sweep*** (**SINGLE** and **RESET** buttons depressed consecutively). However, after each new setting of the **PRE-TRIG.** switch, **RESET** button must be depressed to "arm" the trigger circuit for a single input event or to "write" into store with continuous waveforms.

The **PRE-TRIG.** function can also be used with automatic triggering in the range **0.1 ms/cm** to **50 ms/cm**. However, this is generally not preferred because triggering then occurs at the zero-axis crossing and cannot be changed with the **LEVEL** knob. As already noted, automatic triggering is also inoperable below 30 Hz. Normal triggering should therefore always be preferred (**AT/NORM.** button depressed).

Normal triggering (**AT/NORM** button depressed) is essential ***and*** with single sweep (**SINGLE** and **RESET** buttons depressed) at low signal frequencies with time coefficients of **0.1 s/cm** to **50 s/cm**. Here for each new setting of the **PRE-TRIG.** switch, a new single sweep (depress **RESET** button) must take place.

Each signal display obtained with pre-triggering can be "frozen" with the corresponding **HOLD** button. Both **HOLD I** and **HOLD II** buttons must be depressed for this in the dual mode. The values which were preselected with the **PRE-TRIG.** switch apply only for the trigger channel selected with the **CH I/II-TRIG.I/II** button in the dual mode.

X-Y mode

As already described, the unit is ***switched over to X-Y mode*** – as in real time operation – by pulling out the time base fine control knob. However, some important differences must be noted in the memory mode:

- The X position adjustment can be performed with the **X-POS.** button ***and*** the **Y-POS.II** button. However, it is generally expedient to set the white line on the cap of the **Y-POS.II** knob pointing vertically upwards and to change the X-position with the **X-POS.** button. Otherwise the trace can be restricted to the right or left screen side. The deflection in the memory mode is restricted in the X and Y direction to around 9 cm. Therefore the signal should in no case exceed 8 cm (peak to peak) on the screen. Overdrive in the X direction can be detected easily by left or right sided flattening (clipping). When a horizontal line is overdriven, a bright dot is seen at the end of the line.
- The **CH I/II-TRIG.I/II, DUAL** and **ADD-CHOP.** buttons in the Y section should not be depressed. But the **INV.I** button may be used.
- The **X-MAG.X10** button should not be depressed because otherwise a large dot spacing (approx. 2.9 mm) in the X direction arises.
- The **DOT JOIN** button can be used. It provides greater picture intensity for certain signals.
- If the **HOLD I** button is not depressed, scanning, storage and reading out takes place in the ***refresh mode***. Each signal change is immediately detected. If the **HOLD I** button is depressed, the display visible at the instant of depressing is permanently stored.
- The dot density in the X-Y mode is 256 dots over approx. 9 cm in both directions.
- The most important change compared with the real time mode concerns the ***timebase setting***. The time base is completely switched off in the real time X-Y mode. This is not the case with digital storage because scanning and reading out must take place under certain frequency conditions. A particular timebase setting suits each input signal frequency. If the timebase is set too fast, (**TIME/DIV.** switch turned too far to the right) gaps appear in the signal display. If the switch is turned too far to the left, the display is out of focus and hazy. The correct setting of the switch can be found from

$$\mathbf{Z} = \frac{1}{\mathbf{F} \cdot 10}$$

where:
Z is the time coefficient to be set in ***s/cm*** and **F** the signal frequency in ***Hz***.

Example: **F** = 50 Hz then **Z** = 1 : (50 · 10) = 0.002 = **2 ms/cm**. If **Z** is an intermediate **TIME / DIV.** range not on the switch, use the ***next higher*** coefficient on the **TIME/DIV.** scale. Example: **F** = 1.5 kHz, **Z** = 1 (1 500 · 10) = 0.000067 = 67 µs/cm, use **Z = 0.1 ms/cm** and not: Z = 50 µs/cm). There would be a gap in the signal with a setting at 50 µs/cm. If the signal frequency is not known, there are two other methods for correct time coefficient setting. Switch the X-Y mode off (**STORAGE ON** button remains depressed) and display with one channel on the screen at least 1 signal period over ***10 cm*** graticule width. In the most unfavourable case there should be just on 2.5 periods. This setting is then optimal. For the other method, remain in the X-Y mode and set the timebase so that just ***one*** gap arises in the signal. You see this only correctly if you depress

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and release again the **HOLD I** button several times. Then turn the **TIME/DIV.** switch by ***one*** position to the left. If the two frequencies at the input sockets are different, the time coefficient setting is determined by the higher frequency.

If the signal frequencies are below 2 Hz in the X-Y memory mode, the **TIME ms/s** button must be depressed. **s/cm** are then read off instead of ms/cm in the scale range of the **TIME/DIV.** switch framed by the dashed line. Thus signal frequencies down to 0.002 Hz = 2 mHz can be displayed without gaps in the X-Y mode.
Nevertheless, the complete storage of a signal train lasts 500 s = 8 min 20 seconds.

However, a sudden signal change is detected immediately in the refresh mode by the junction in the wave train. Very slow changes can be measured by using the second memory. After the first signal is fully written, first press the **HOLD I** button, then operate the **2. STOR.** button and release the **HOLD I** button. Press the **HOLD I** button again after a fixed time interval. Both waveforms can now be compared and evaluated by alternately releasing and depressing the **2. STOR.** button.

Plotter output

The HM 208 has a plotter output for connecting a XY plotter. The sensitivity in both X and Y directions is ***0.1 V/cm*** (±10%) each. It refers to the screen deflection with the **X-MAG.X10** button not depressed (the depressed button effects only the screen, not the plotter output). The outputs have internal resistance of approx. 100 Ohm. Because commercially available XY plotters have quite different maximum ***plotting speeds***, the output speed of the plotter output can be ***adjusted in three steps*** in the interior of the HM 208:

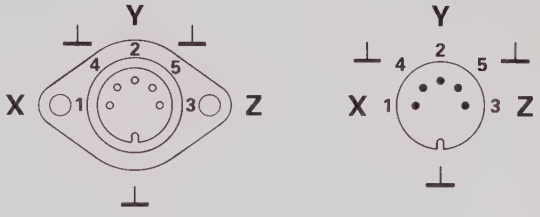
Single channel mode (CH.I):	10-20-40 s/cm
Algebraic addition (CH.I ± CH.I):	10-20-40 s/cm
Single channel mode (CH.II):	5-10-20 s/cm
Dual mode (CH.I and CH.II):	5-10-20 s/cm
X-Y mode:	5-10-20 s/cm

The change by the factor of 2 occurs automatically on switching on the mode concerned. The 3 way slide switch is located on the ***right side*** of the unit between two circuit boards (distance 250 mm from the plastic front edge, around at mid height). It can be easily operated after removing the casing (see servicing instructions). The larger output speed is always towards the rear of the casing. The slowest plotting speed is always set in the factory.

Penlift control: An open collector control circuit (max. + 100 mA) in the HM 208 supplies the penlift instruction for the plotter. If current flows (voltage is supplied by the XY plotter), the pen is set on the plotting film.

Connection diagram: Since there are currently no uniform connection sockets for XY plotters, no connection cable can be supplied with the HM 208. You must make it yourself. A 5 pole DIN socket illustrated below is fitted on the rear panel of the HM 208.

Socket (front) **Plug (soldering side)**



Connections: 1 = X; 4 = ground (X)
2 = Y; 5 = ground (Y)
3 = Z; casing ground (Z)

The penlift control is marked with Z. A cable with 3 shielded conductors is suitable. But 2 shielded cables with an extra wire for Z can also be used. Plug according to DIN 41524, 5 pole.

Operation: The plotter output is only enabled if the **HOLD** buttons corresponding to the mode are depressed so that the signal remains permanently stored. If the associated **PLOT** button is now depressed, the penlift output is released, the pen of the XY plotter is applied with a slight delay and plotting starts. A bright dot simultaneously traces the plot on the screen of the HM 208. When the stored signal is plotted, the full signal display reappears automatically on the screen, the pen is lifted and the XY plotter stops. The oscilloscope controls should not be operated during plotting!

A current plotting process can be interrupted at any time by depressing the **RESET** button. The complete signal display reappears immediately on the screen. If the corresponding **PLOT** button is depressed again, a complete plotting process restarts.

The two stored signal waveforms must be output in two plotting processes in the dual mode. **PLOT I** is depressed first for this purpose. **PLOT II** is depressed when the double signal display reappears on the screen. Naturally the sequence can also be reversed. If the second signal is to be plotted about the same X axis (abscissa), the plotting film must be wound back to the starting point of the first signal. This is not required for XY plotters with fixed plotting sheet. A YT plotter can also be used in principle, but only an XY plotter can be used in conjunction with the X-Y mode of the oscilloscope.

Short instruction for HM208 in real time mode

Switching on and setting up

Connect oscilloscope to power outlet, depress red **POWER** button (above right next to the screen).
LED indicates operating condition.
Casing, chassis and all measuring connectors are connected with the safety earth conductor (Safety Class I).
Do not depress any further buttons.
TRIG. selector switch to **AC**, input coupling switch to **GD**.
Set **TIME/DIV.** switch to **50 µs/cm**.
Set mean intensity with **INTENS.** knob.
Center trace on screen using the **Y-POS.I** and **X-POS.** knobs.
Then focus trace with **FOCUS** knob.

Vertical amplifier mode

Channel I: All buttons in the Y section in out position.
Channel II: **CH.I/II-TRIG.I/II** button depressed.
Channel I and II: **DUAL** button depressed.
Alternating channel switchover: do not depress **CHOP.** button.
Chop mode (for signals <1 kHz): depress **CHOP** button in addition.
Sum (Channel II + I): depress only **ADD** button.
Difference (Channel II − I): depress only the **ADD** and **INV.I** button.

Triggering mode

Select trigger mode with **AT/NORM.** button.
Automatic triggering (for signals >30 Hz): do not depress **AT/NORM.** button.
Normal triggering: depress **AT/NORM.** button. Set trigger point with **LEVEL** knob.
Trigger edge direction: select with **+/−** button.
Internal triggering: do not depress **EXT.** button.
In the dual mode and with algebraic addition, free trigger channel selection with **CH.I/II-TRIG.I/II** button.
External triggering: depress **EXT.** button. Apply synchronous signal ($0.3\,V_{pp} - 3\,V_{pp}$) to **TRIG. INP.** socket.
Synchronous signal $3\,V_{pp} - 30\,V_{pp}$: depress **10:1** button.
Line triggering: set **TRIG.** selector switch to ~.
Select trigger coupling with **TRIG.** selector switch. Trigger frequency ranges:
AC: 20 Hz − 10 MHz; **DC**: 0 − 10 MHz; **HF**: 1 kHz − 40 MHz; **LF**: 0 − 1 kHz.
Composite video signal with line frequency: **TRIG.** selector switch to **AC** (possibly **DC**).
Composite video signal with frame frequency: **TRIG.** selector switch to **LF**.
Note trigger indication: lamp above **TRIG.** selector switch.
Lights up on triggering. Flashes at trigger signals <10 Hz if triggered.

Measurements

Apply test signal to the vertical input connectors of **CH.I** and/or **CH.II**.
Before use, calibrate attenuator probe previously with built-in square wave generator **CAL.**
Switch test signal coupling to **AC** or **DC**.
Adjust signal to desired display height with attenuator switch.
With signals < $1.5\,mV_{pp}$, switch on Y expansion x5: pull out Y fine control knob **MAG X5**.
Select time coefficient on the **TIME/DIV.** switch.
Set trigger point with **LEVEL** knob for normal triggering.
Amplitude measurement with Y fine control at right stop (**CAL.**).
Time measurement with time fine control at right stop (**CAL.**).
Time expansion X10 with **X-MAG. X10** button depressed.
External horizontal sweep (***X-Y mode***) with **X-Y** fine time control knob pulled out (X input: **CH.II**).

Memory mode

See memory mode operating instruction page M15. Memory modes see M16 ff.

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Front Panel Elements HM208

Front Panel Element	Function
❶ **POWER on/off** (pushbutton switch and power LED)	Line master switch Power **on** is indicated by illuminated LED.
② **INTENS.** control	Intensity control for adjustment of CRT display brightness.
③ **TR** (Trimmer Pot.)	Trace Rotation – used to correct trace angle versus raster.
④ **FOCUS** control	Control to adjust display focus (sharpness).
⑤ **ILLUM.** – 0, 1, 2 (3-position slide switch)	Controls graticule illumination. Off, dim, bright.
⑥ **1 kHz – 1 MHz** (pushbutton switch)	Selects calibrator frequency 1 kHz or 1 MHz.
⑦ **CAL. 0.2 V-2 V** (test sockets)	Calibrator square-wave signal source.
⑧ **X-MAG. X10** (pushbutton switch)	Trace magnifier – expands the X-axis by a factor of 10.
⑨ **X-POS.** control	Adjusts horizontal position of trace.
⑩ **Y POS I, Y POS II** (control pots.)	Adjusts vertical position of trace for Channel I and Channel II.
⑪ **CH. I,** DC, AC, GD **CH. II,** DC, AC, GD (3-position slide switch)	Input coupling selector switch for each channel. DC – direct connection, AC – via capacitor, GD – Y preamplifier grounded (signal disconnected).
⑫ **CH I (II)** BNC sockets and supplementary ground sockets	Signal input for Channel I (left) and Channel II or horizontal X-input (right). Input impedance: 1 MΩ ∥ 30 pF.
⑬ **VOLTS/DIV.** Input altenuator (12-position rotary switch)	selects the Y input sensitivity and indicates the scale factor of vertical display in V/cm and mV/cm.
⑭ Amplitude variable control (center pot.)	For fine adjustment of vertical amplitude (Channel I or II). Decreases Y sensitivity by a factor of 2.5 (left stop). Should normally be reset to CAL. position (right stop).
⑮ **MAG X5** (push-pull switch)	Increases Y sensitivity by a factor of 5 in pulled position
⑯ **INV. I** (pushbutton switch)	Inverts display of Channel I. In combination with ADD button ⑲ the difference of two signals is displayed.
⑰ **CH I/II – TRIG. I/II** (pushbutton switch)	Mono: button released – display and internal triggering from Channel I. Button depressed – display and internal triggering from Channel II. Dual: button released – internal triggering from Channel I. Button depressed – internal triggering from Channel II.
⑱ **DUAL** (pushbutton switch)	Selects single (MONO) or dual trace (DUAL) operation. When depressed = DUAL.
⑲ **ADD – CHOP.** (pushbutton switch)	Selects alternate or chopped display in DUAL mode. In MONO mode display of the sum or difference (⑯ depressed in addition) of two signals.
⑳ **TRIG.** AC-DC-HF-LF-~ (slide switch)	Selects trigger coupling: AC: 20 Hz-10 MHz; DC: 0-10 MHz; HF: 1 kHz-40 MHz; LF: 0-1 kHz; set to ~ for line triggering.

Front Panel Element	Function
⑳ **TRIG.** (LED indicator)	Trigger lamp to indicate when timebase is triggered. Flashes when frequency < 10 Hz.
㉑ **+/–** (pushbutton switch)	Switch to select triggering on positive- or negative-going edge of signal.
㉒ **TIME/DIV.** (18-pos. rotary switch)	Timebase selector switch. (0.2 µs/cm to 100 ms/cm).
㉓ Timebase variable control (center pot.)	Timebase variable control for fine adjustment. Decreases deflection by a factor of 2.5 (left stop). Should normally be reset to CAL. (calibrated) position.
㉔ **X-Y** (push-pull switch)	Selects X-Y operation. Switches off the internal timebase generator and connects Channel II (HOR. INP.) to the X amplifier.
㉕ **EXT.** (pushbutton switch)	Selects external trigger mode. Trigger signal input to ㉙ (TRIG. INP.) Inp. signal 0.3 V-3 V_{pp}.
㉖ **10:1** (pushbutton switch)	Attenuator for external trigger signal. When depressed, input signal 3 V-30 V_{pp} at ㉙.
㉗ **AT/NORM.** (pushbutton switch)	Release for automatic triggering (signals > 30 Hz). Push for normal triggering. Adjust with LEVEL knob ㉘.
㉘ **LEVEL** (control pot.)	Control for adjusting trigger level when AT/NORM. depressed ㉗.
㉙ **TRIG. INP.** (BNC connector)	Input for external trigger source. Button EXT. ㉕ depressed. Input impedance 1 MΩ ∥ 30 pF.

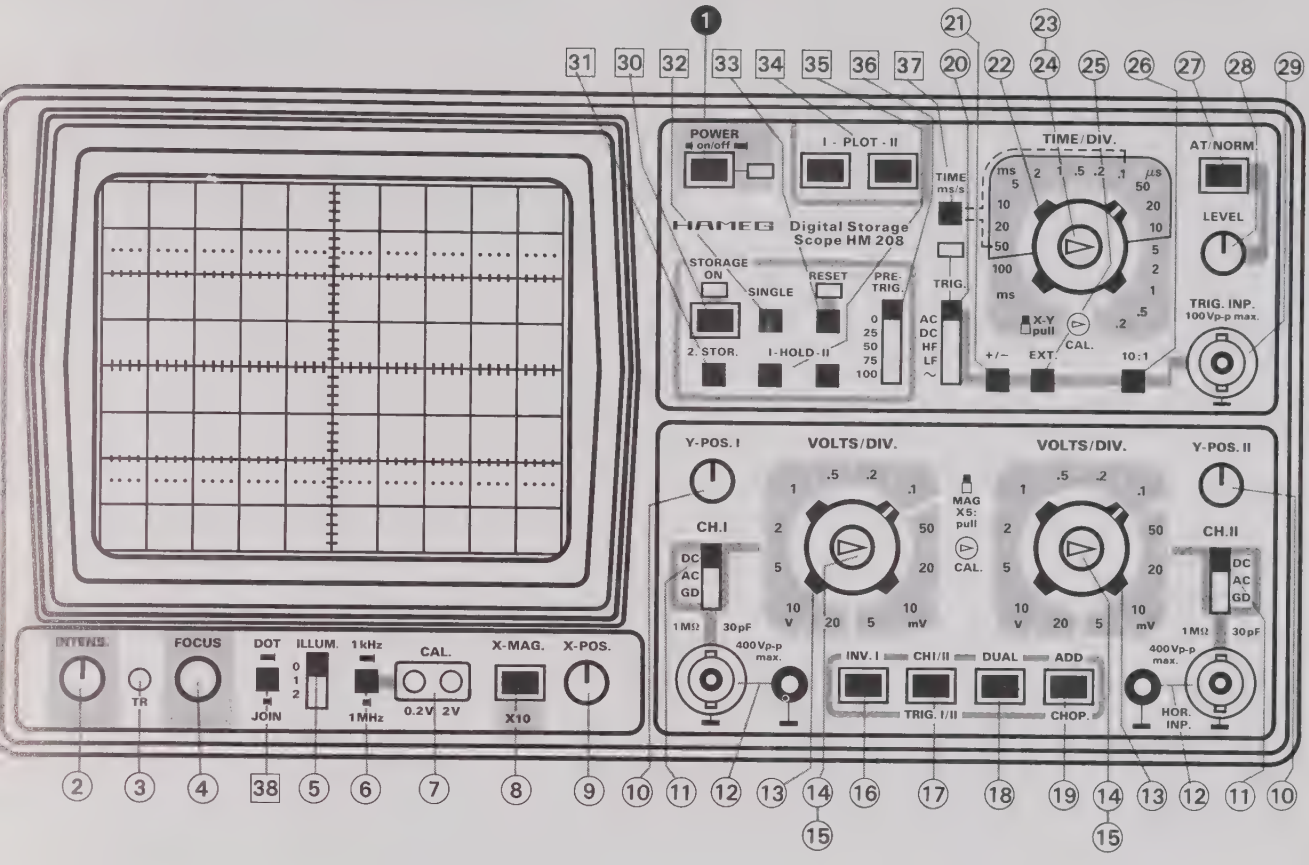
Controls for memory mode (refer to page M 15)

30 **STORAGE ON** (pushbutton and LED)	Release for real time mode. Push for memory mode (LED illuminated). LED flashes at incorrect timebase settings.
31 **2. STOR.** (pushbutton switch)	Activates second storage when depressed.
32 **SINGLE** (pushbutton switch)	Switches memory time base to single sweep operation (button depressed). Next following trigger signal initiates the single sweep (refer to 33).
33 **RESET** (pushbutton; LED)	Arms oscilloscope for single sweep operation (indicated by LED). LED goes out on triggering.
34 **I-PLOT-II** (pushbuttons)	Each button activates an external XY plotter. (In combination with 35).
35 **I-HOLD-II** (pushbuttons)	Serve for holding memory contents of each channel. Ready for plotting (34).
36 **PRE-TRIG.** 0-25-50-75-100 (slide switch)	Advances the start of the memory timebase. Triggerpoint shifted on the screen (values in percent).
37 **TIME ms/s** (pushbutton switch)	Time coefficients (bounded by the dashed line) are extended 1000-fold. In combination with ㉗ "roll mode" is possible.
38 **DOT JOIN** (pushbutton switch)	Joins a stored sequence of points by bright lines when depressed.

Controls located underneath the instrument

DC-Balance CH I, CH II (trimmer pot).)	To adjust DC balance of the vertical (Y) preamplifiers.

Subject to change without notice



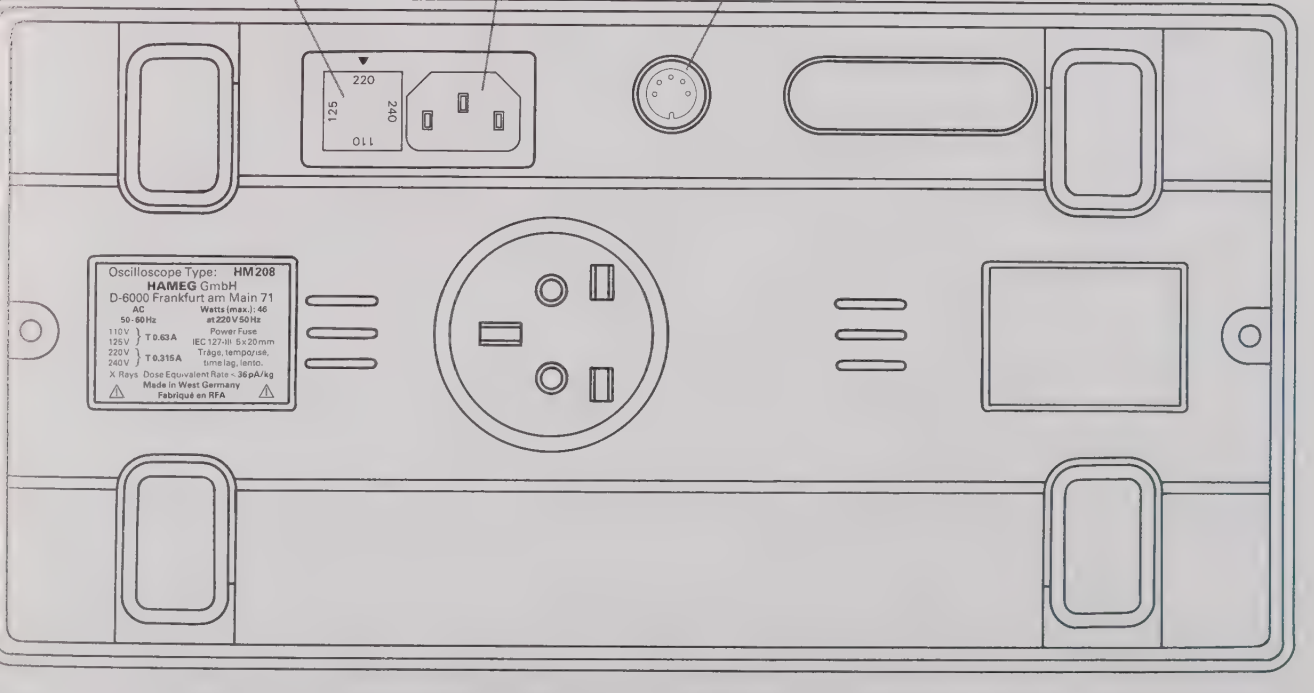
Netzspannungs-Umschaltung; Sicherungshalter

Mains / Line Voltage Selector Fuse Holder

Kaltgerätestecker Power Plug-In Unit

Plotterausgang Plotter Output

Rückseite Rear View



General

No service or calibration work should be carried out on the HM208 without sufficient expert knowledge. This concerns the digital memory part in particular. It is advisable to have any faults rectified by the fast and economical HAMEG service organization. We recommend shipping instruments back to HAMEG for repair only in the original carton (see also "Warranty" page M2).

Opening the instrument

Firstly pull out the power cord socket from the built-in appliance inlet. Slacken the two screws on the rear cover of the casing and withdraw this to the rear. Holding the casing firmly, pull out the chassis by the front panel molding. When the instrument is assembled later, pay attention that the casing is seated behind the edge of the front molding lip on all slides. The same also applies for replacing the rear cover.

Warning
When opening or closing the casing, when repairing or when exchanging parts, the instrument must be isolated from all voltage sources. If measurement, fault finding or calibration on the opened instrument is unavoidable, this should only be performed by an expert who is familiar with the risk involved.

When working on in the HM208, pay attention that the operating voltage of the CRT is approx. 14kV and that of the output stages around 70V. Potentials up to approx. 2000V are located on the tube socket and mainly on the Z board. They are a hazard to life. Therefore the greatest care must be taken. It is further pointed out that short circuits at different points in the CRT high-voltage circuit may result in the simultaneous failure of various semi-conductors and or the optocoupler. For this reason, the connection of capacitors to these points with the instrument switched on is very dangerous.

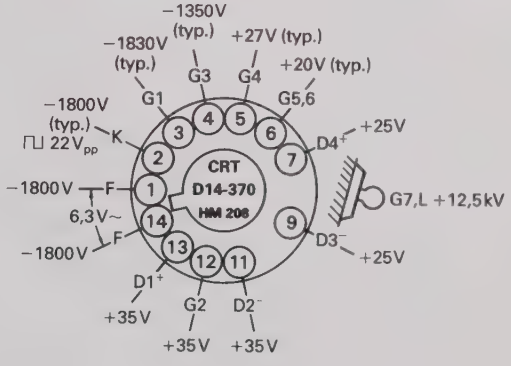
Capacitors in the instrument can still be charged even if the unit has been isolated from all voltage sources. Normally the capacitors are discharged 6 seconds after switching off. However, the load on a supply could become open circuited on a defective unit causing the supply capacitors to remain charged. Hence, corresponding precautionary measures must be taken.

The post-acceleration connection of the CRT remains at a high voltage even a lengthy time after switching off. When testing this connection or removing the CRT, pull the plastic coated clip (left next to the screen) out from the tube and discharge it against a side part of the chassis. The exposed high voltage contact of the tube must then be short circuited against the chassis with, for instance, a long insulated screw driver, in which case the wired tube socket should be left on the tube base. This short circuit should be repeated several times (important when changing tubes!).

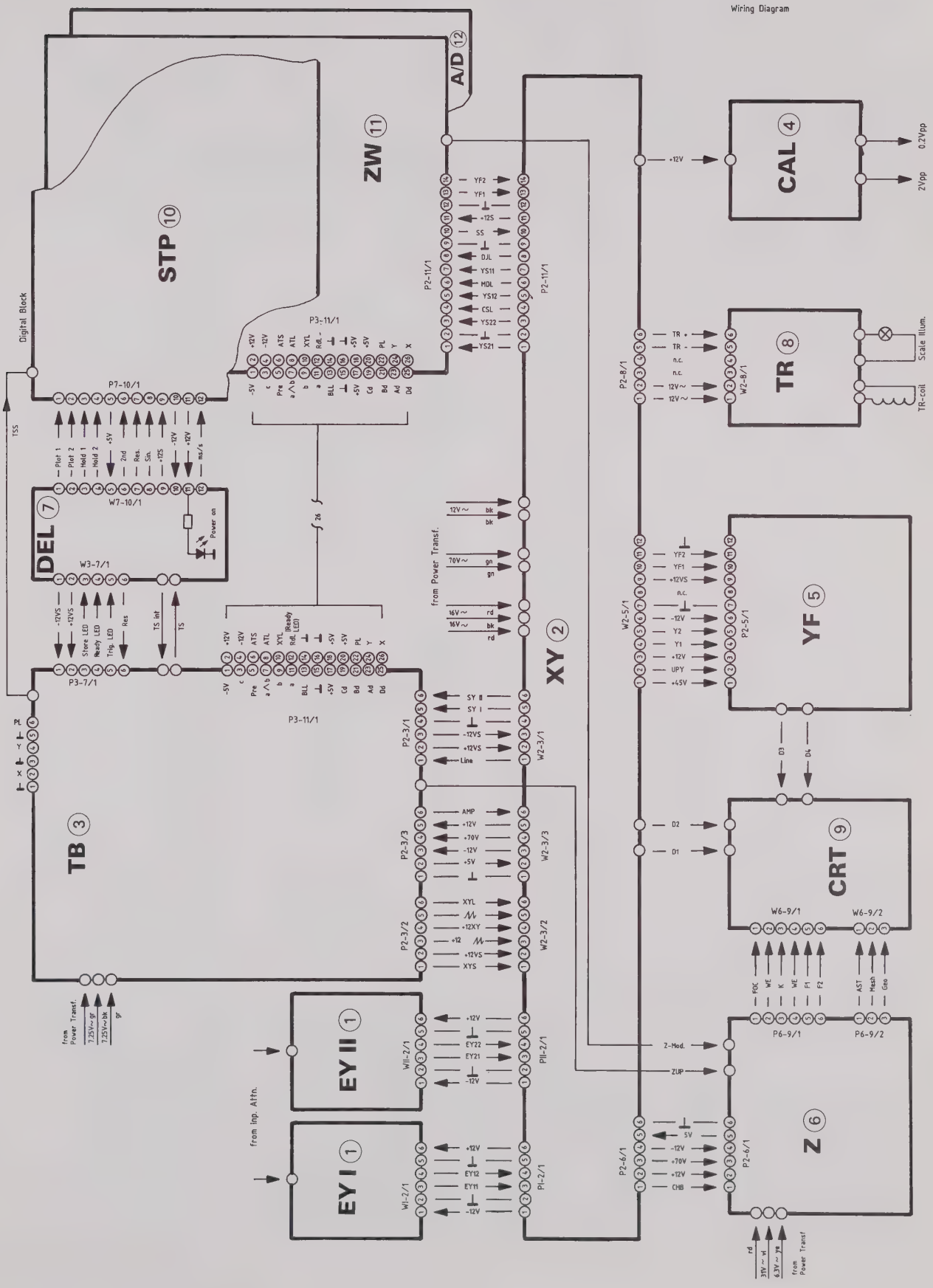
Handling of the CRT needs utmost caution. The glass bulb must not be allowed – under any circumstances – to come into contact with hardened tools, nor should it undergo local superheating (e.g. by soldering iron) or local undercooling (e.g. by cryogenic-spray). We recommend the wearing of safety goggles (implosion danger).

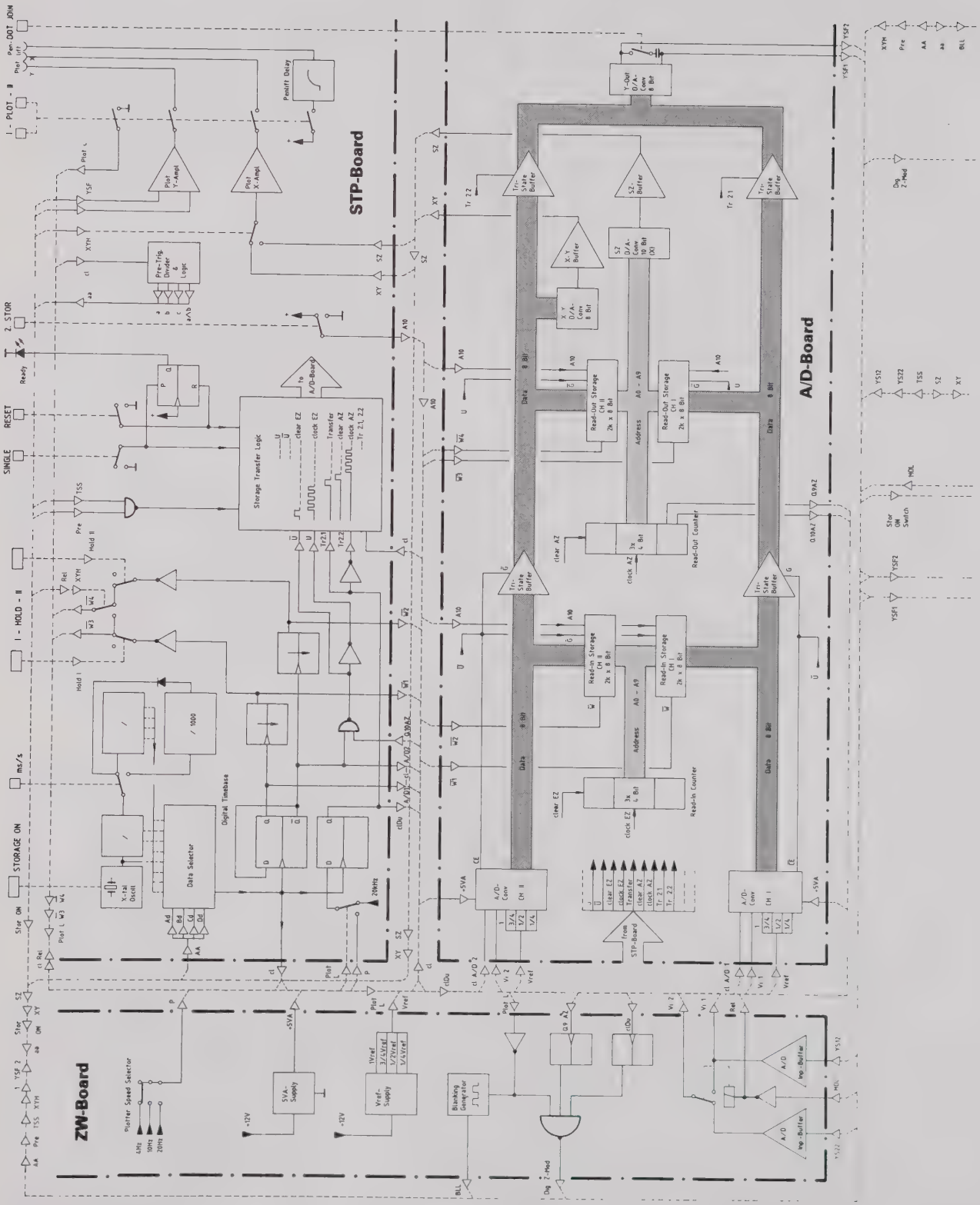
Operating voltages

Apart from the two a.c. voltages for CRT heating (6.3V) and graticule illumination or line triggering (12V), five operating d.c. voltages are generated in the HM208. They are all electronically regulated or stabilized (+5V, +12V, −12V, +70V and 22V for the unblanking circuit). The high voltage converter which supplies the −1900V and +12.5kV voltages is driven from the direct voltage +12V and −12V. Only the +12V voltage, which serves as voltage reference for the other stabilized voltages, can be adjusted. Only a sufficiently high impedance voltmeter (>10MΩ) may be used for measuring the −1900V high voltage and the 22V unblanking supply (as a difference between two voltage measurements against ground). It is essential that it has sufficient breakdown strength. We do not advise measuring the post acceleration voltage of 12.5kV. It requires a x1000 HV attenuator with a 1GΩ input impedance and special knowledge. It is recommended when checking the operating voltages also to check their hum or interference voltages. Too high hum levels can frequently be the cause of faults which are otherwise unexplainable.

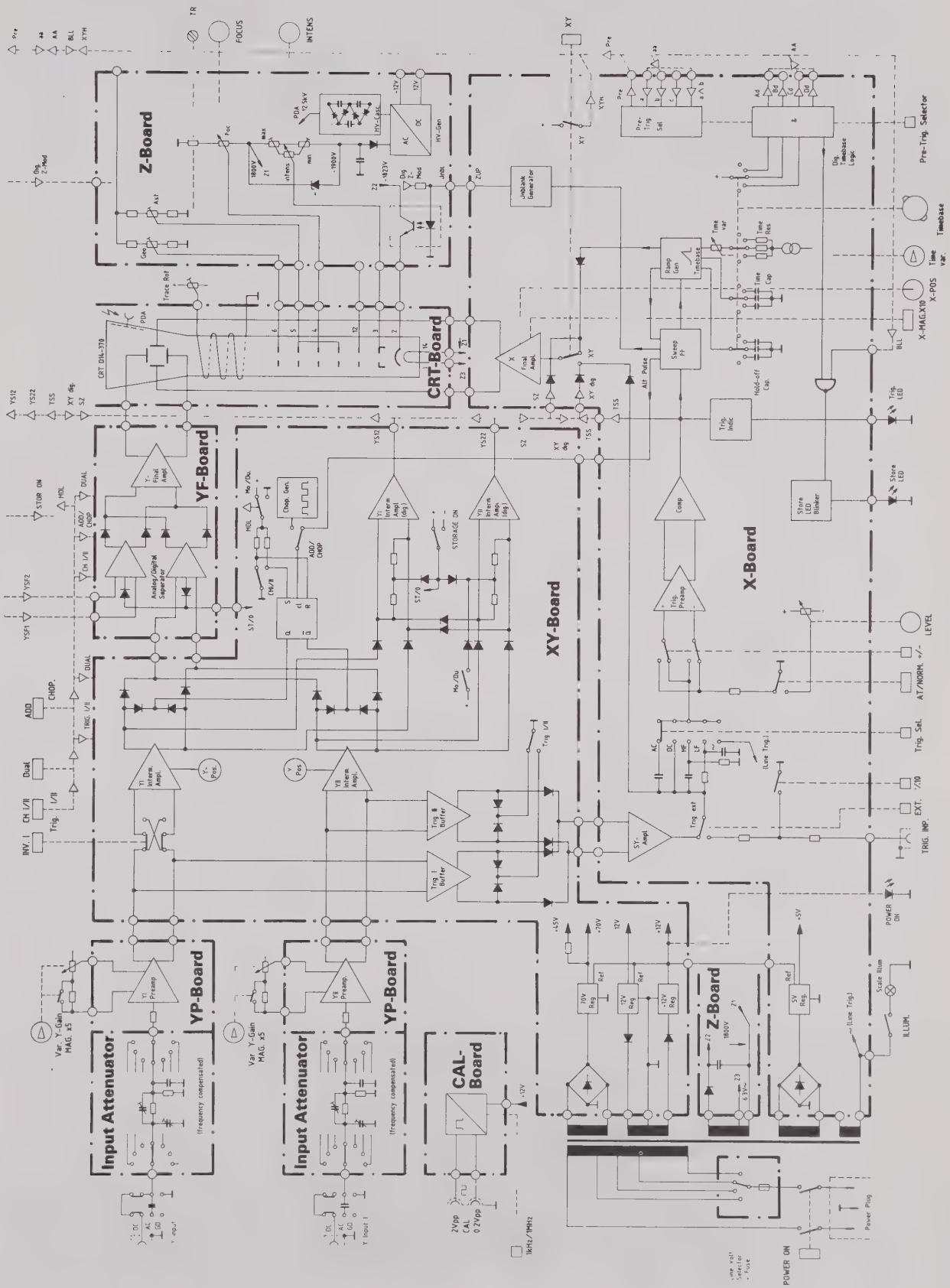


Voltages at the CRT socket.


Wiring Diagram
STP 10
ZW 11
A/D 12
XY 2
CAL 4
TR 8
YF 5
DEL 7
TB 3
CRT 9
Z 6
EY I 1
EY II 1
Digital Block
from Power Transf.
from Inp. Attn.
TR-coil
Scale Illum.
0.2Vpp
2Vpp



Änderungen vorbehalten / Subject to change without notice


Z-Board
CRT-Board
YF-Board
XY-Board
X-Board
YP-Board
YP-Board
CAL-Board
Z-Board
Input Attenuator
Input Attenuator
FOCUS
INTENS
TR
Pre-Trig. Selector
Time/base
X-POS
X-MAG.X10
LEVEL
AT/NORM. +/-
Trig. Sel.
EXT. :10
TRIG. INP.
POWER ON
ILLUM.
Power Plug
POWER ON
Var. Y-Gain MAG. x5
Var. Y-Gain MAG. x5
2Vpp CAL 0.2Vpp
1kHz/1MHz

Bezeichnung der Bauteile

HM208

Identification of electrical components

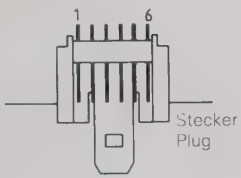
	Bauteile-Nr. Component-No.		Auf Board # On Board #
Analog			
Y (Kanal I)	100...	Y (Channel I)	EY I ①, XY ②
Y (Kanal II)	200...	Y (Channel II)	EY II ①, XY ②
Y Endverstärker	300...	Y Final Amplifier	YF ⑤
Triggerung	400...	Triggering	TB ③, DEL ⑦
Zeitbasis	500...	Timebase	TB ③
Schalter, Anzeigen für Speicherbetrieb	600...	Switches, Indicators for Storage Mode	DEL ⑦
X Endverstärker	700...	X Final Amplifier	XY ②
Calibrator	800...	Calibrator	CAL ④
Hochspannung, Helltastung Strahldrehung, Rasterbeleuchtung	900. .	High Voltage, Unblanking Trace Rotation, Graticule Illumination	Z ⑥ TR ⑧
Netzteil	1000...	Power Supply	XY ②, TB ③
CRT-Sockel	-	CRT Socket	CRT ⑨
Digital			
A/D-Wandler	600...	A/D Converter	A/D ⑫
Dunkelsteuerung, Y-Zwischenverstärker, V_{ref}-Netzteil	631...	Blanking Circuit, Y Intermediate Amplifier, V_{ref} Supply	ZW ⑪
Digitale Zeitbasis, Plottersteuerung, Ausleselogik, Pre-Trigger- und Umspeicherlogik	6000...	Clock and Timing, Plotter- and Readout Control, Pre-Trigger and Storage Transfer Logic	STP ⑩

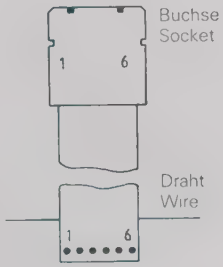
Abkürzungen / Abbreviations

AI...	Gerätestecker	/ Appliance inlet
BR...	Bruckengleichrichter	/ Bridge rectifier
C..	Kondensator	/ Capacitor
ChP ..	Testpunkt	/ Check point
CN...	Steckverbinder	/ Connector
CRT...	Kathodenstrahlröhre	/ Cathode-ray tube
D...	Diode	/ Diode
F. .	Lötöse	/ Eyelet
F..	Sicherung	/ Fuse
IC..	Integr. Schaltung	/ Integrated Circuit
L ..	Spule, Drossel	/ Inductor, Coil
LED...	Leuchtdiode	/ Light emittig diode
NTC ..	NTC-Widerstand	/ NTC resistor
P.	Stecker	/ Plug
R ..	Widerstand	/ Resistor
S..	Schalter	/ Switch
T..	Transistor	/ Transistor
TR...	Transformator	/ Transformer
VC .	Trimmkondensator	/ Variable capacitor
VR...	Potentiometer	/ Variable resistor
VVC...	Kapazitätsdiode	/ Voltage variable capacitor
W ..	Draht	/ Wire
Z..	Zenerdiode	/ Z-Diode

TB-Board 3..

P2-3/1





W2-3/1

Y-Board 2..

Widerstand- / Resistor identification

- Widerstand / Resistor 0.25 W 2 % (carbon film)
- Widerstand / Resistor 0.25 W 1 % tc = $50 \cdot 10^{-6}$/K (metal film)
- Widerstand / Resistor 0.25 W 0.5 % tc = $50 : 10^{6}$/K (metal film)
- Widerstand / Resistor 0.5 W 2 % (carbon film)
- 4 Widerstand / Resistor 4 W 2 % tc = $400 \cdot 10^{-6}$/K (metal oxide film)

Beispiel: P2-3/1-5 bzw. W2-3/1-5

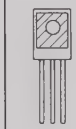
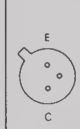
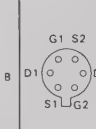
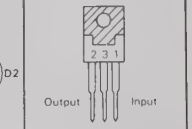
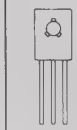
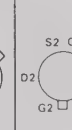
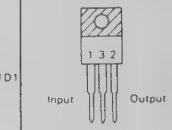
P = Flachkabelstecker (auf Board ..)
W = Flachkabelverbindung: eine Seite verlötet, andere Seite Buchsenleiste
2-3 = Verbindung zwischen Board 2 und Board 3
1 = 1. Flachkabelverbindung zwischen Board 2 und 3
5 = Draht-Nummer des Flachkabels

Example: P2-3/1-5 or W2-3/1-5 respectively

P = Flat cable plug (soldered on board)
W = Flat cable wiring (directly soldered on board) with socket (movable)
2-3 = Connection between Board 2 (Y-Board) and Board 3 (TB-Board)
1 = First flat cable connection between Board 2 and 3
5 = Serial number of the wire (in the flat cable)

Farbkennzeichnung der Anschlußdrähte / Color-Abbreviations for insulated wire

bk	= schwarz	/ black	ye	= gelb	/ yellow	gr	= grau	/ grey
bn	= braun	/ brown	gn	= grün	/ green	wh	= weiß	/ white
rd	= rot	/ red	bl	= blau	/ blue	trp	= transparent	/ transparent
or	= orange	/ orange	vi	= violett	/ violet	gn/ye	= grün-gelb	/ green-yellow stripe

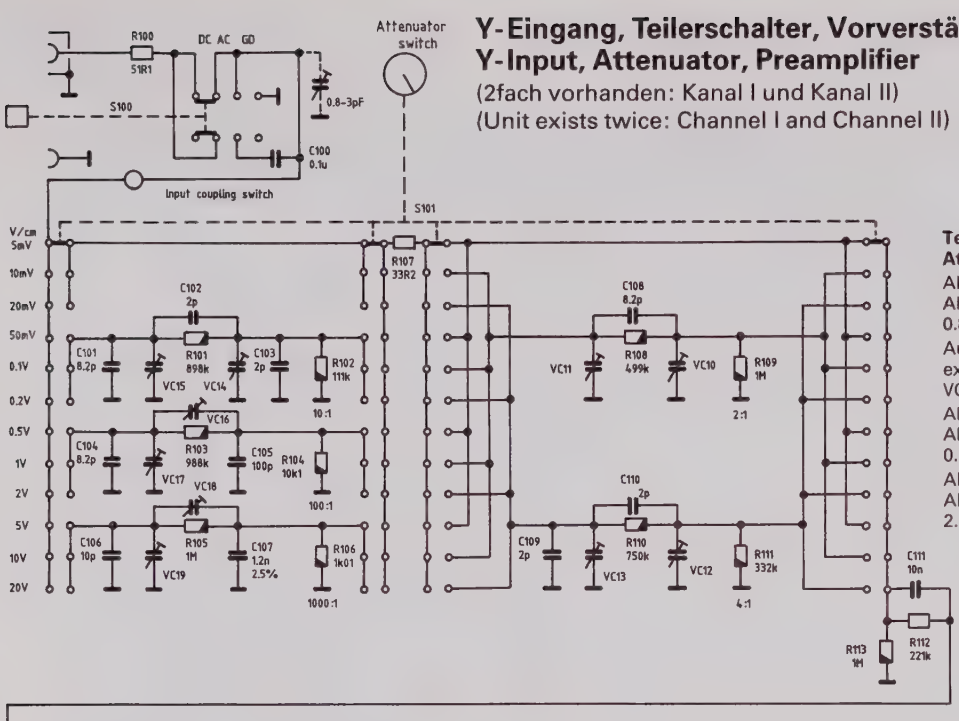
Anschlußfolge der Transistoren **Terminals of Transistors**	BC 237 B BC 550 C BC 557 B BC 547 C BF 297	BF 199 BF 440	BF 422 BF 423	BF 458 BF 459 BUX 86/87 BD 232	BSX 19	L 440	78 XXCU
Ansicht von unten **Bottom View**							
Ansicht von oben **Top View**							

Änderungen vorbehalten / Subject to change without notice

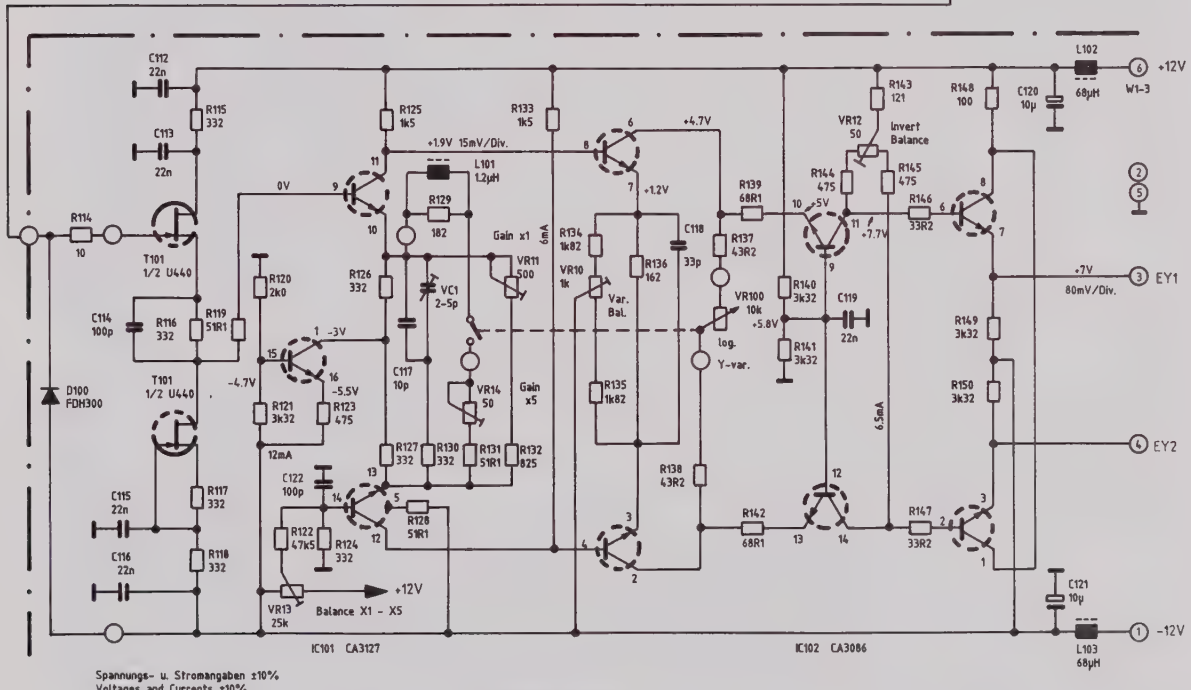
Y-Eingang, Teilerschalter, Vorverstärker
Y-Input, Attenuator, Preamplifier

HM 208

(2fach vorhanden: Kanal I und Kanal II)
(Unit exists twice: Channel I and Channel II)

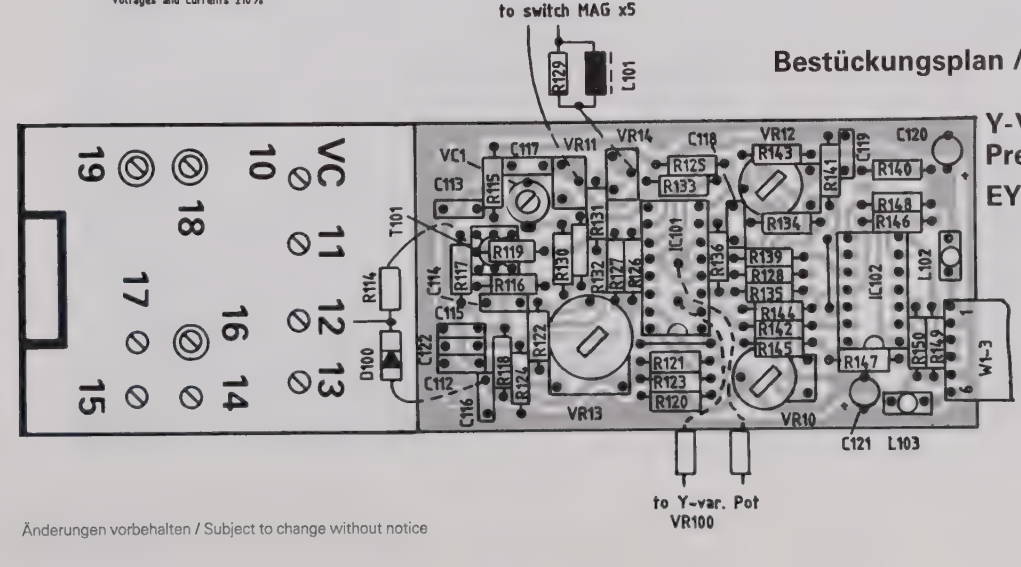


Teilerschalter:
Attenuator:
Alle Trimmer
All trimmers
0.8–3pF $t_c = -300 \cdot 10^{-6}$/K 400V
Ausnahme
except
VC14: 1–5.5pF $t_c = -300 \cdot 10^{-6}$/K 400V
Alle Widerstände
All resistors
0.5%, $t_c = 50 \cdot 10^{-6}$/K 0.25W
Alle Kondensatoren (bis 10pF)
All capacitors (up to 10pF)
2.5% ± 0.25% t_c = NPO 400V



Spannungs- u. Stromangaben ±10%
Voltages and Currents ±10%

Bestückungsplan / Comp. Locations

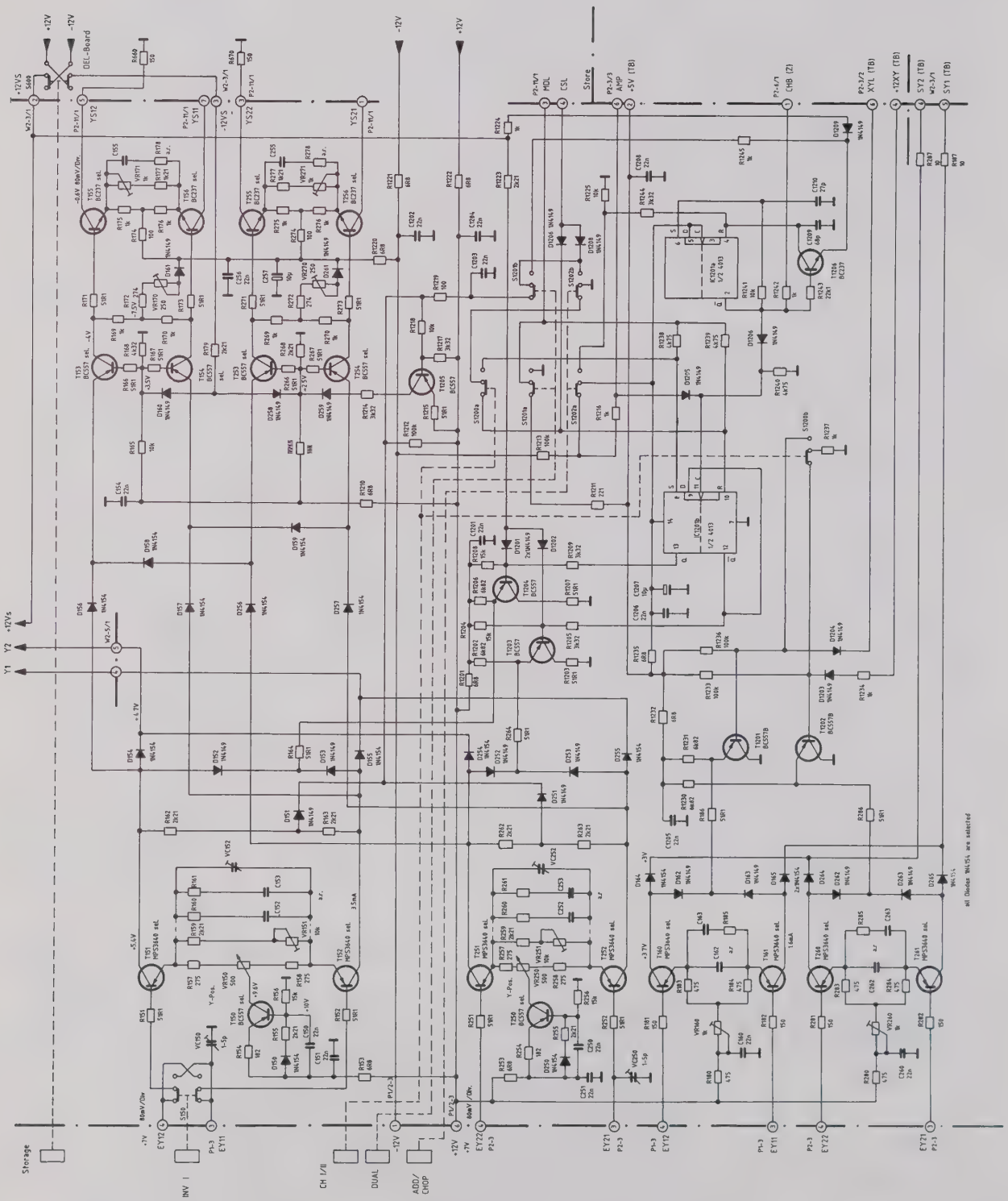


Y-Vorverstärker
Preampl. Board Unit
EY-Board

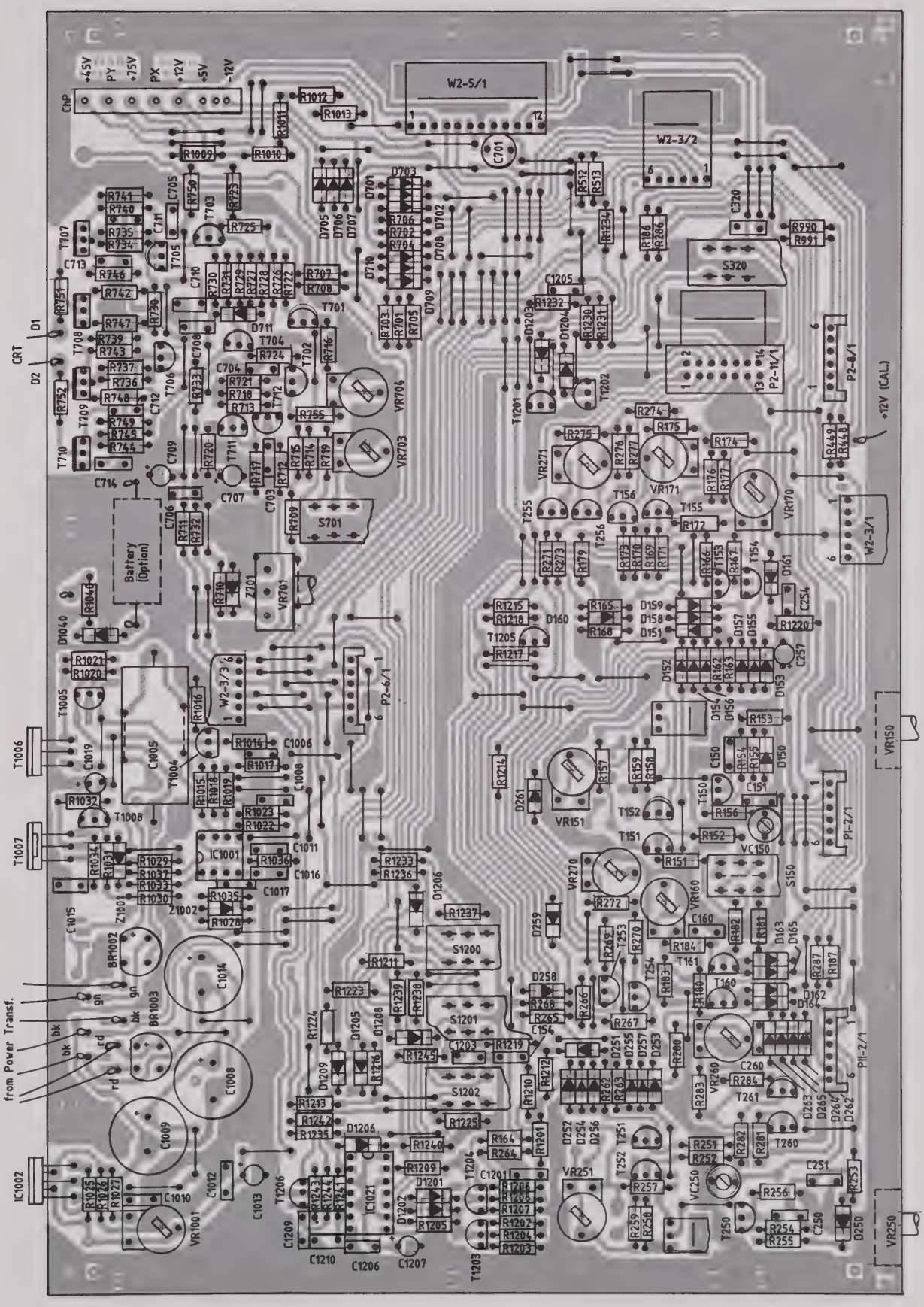
Y-Zwischenverstärker Kanal I und II, Kanal Flip-Flop Chopper Generator, Steuerlogik

Y-Intermediate Amplifier Ch. I and Ch. II, Channel Flip-Flop, Chopper Generator, Gates

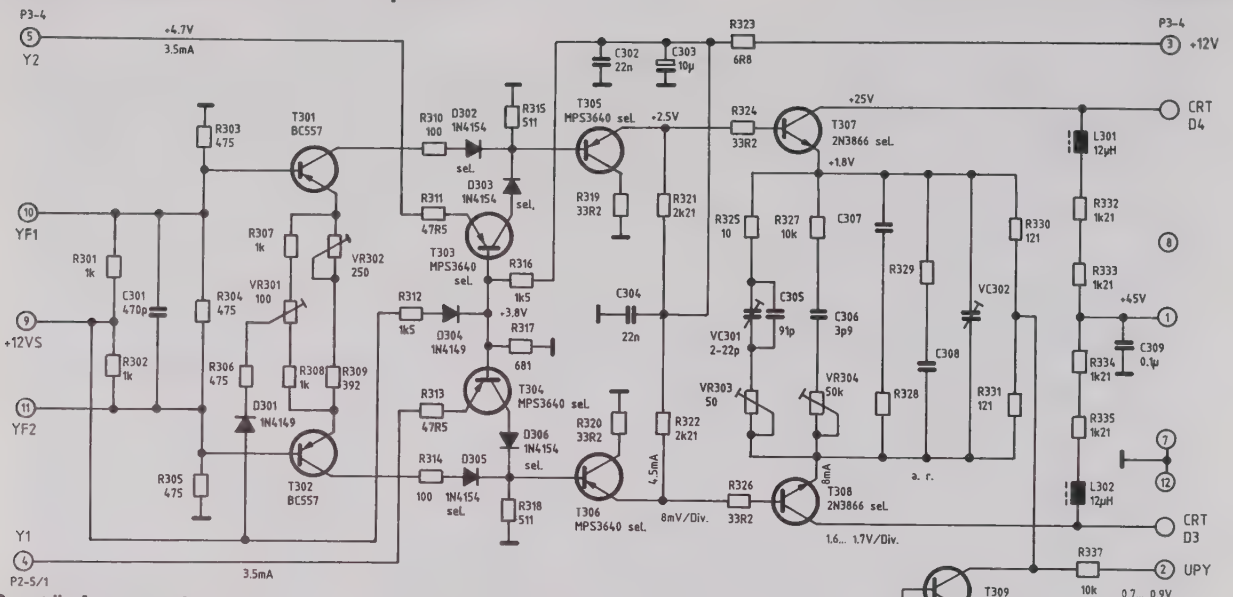
HM208



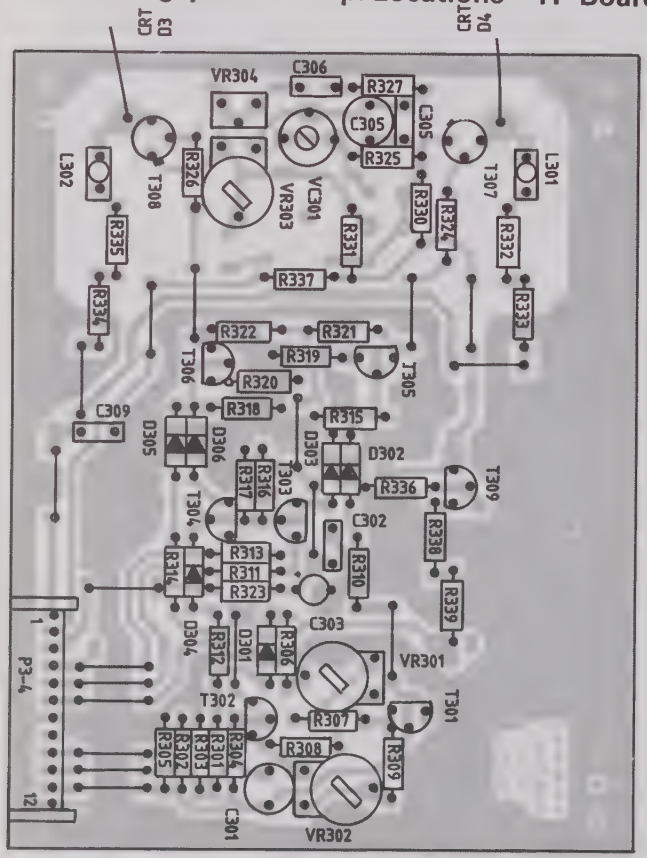
Änderungen vorbehalten/Subject to change without notice

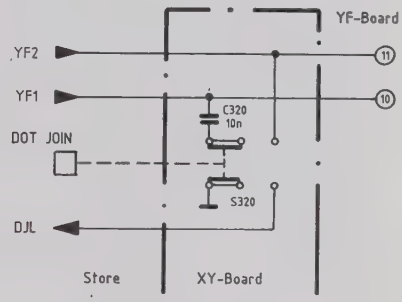

CHP
+45V
PY
+75V
PX
+12V
+5V
-12V
W2-5/1
W2-3/2
S320
P2-11/1
P2-8/1
+12V (CAL)
W2-3/1
P11-2/1
P2-6/1
W2-3/3
Battery (Option)
S701
S1200
S1201
S1202
VR150
VR151
VR171
VR251
VR270
VC150
VC250
VR1001
IC1001
IC1002
from Power Transf.
CRT
D1
D2

Y-Endverstärker / Y-Final Amplifier

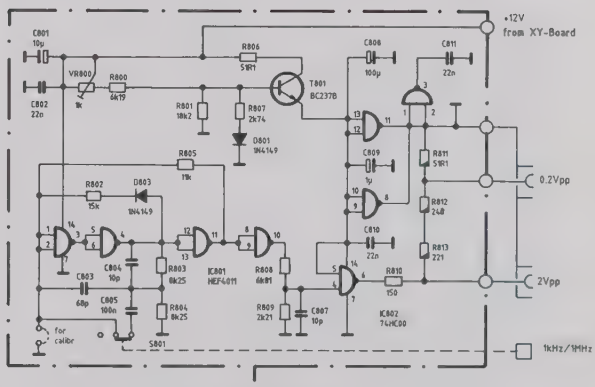


Bestückungsplan / Comp. Locations YF-Board

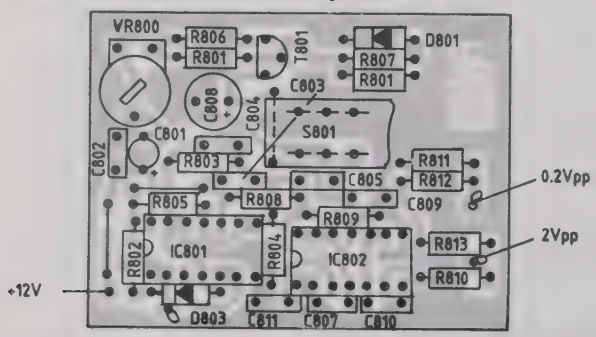


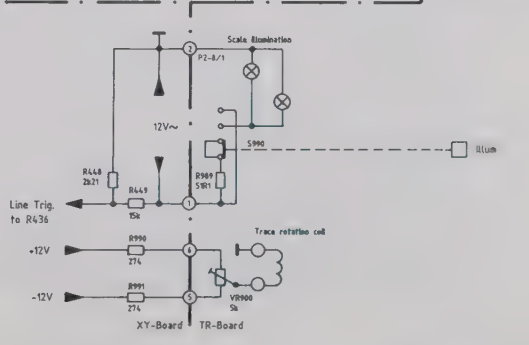


Calibrator HM 208

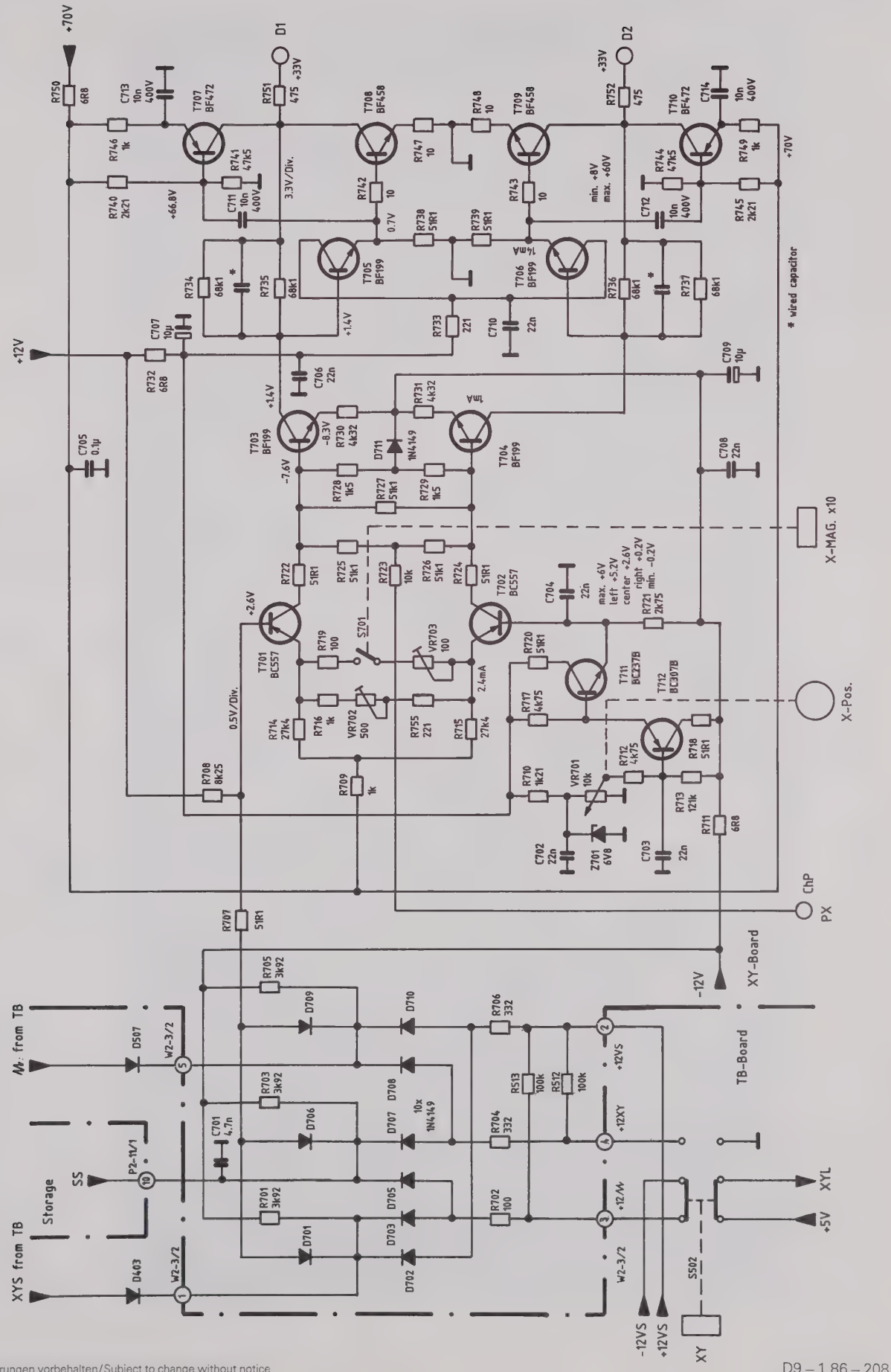


Bestückungsplan / Comp. Locations CAL-Board



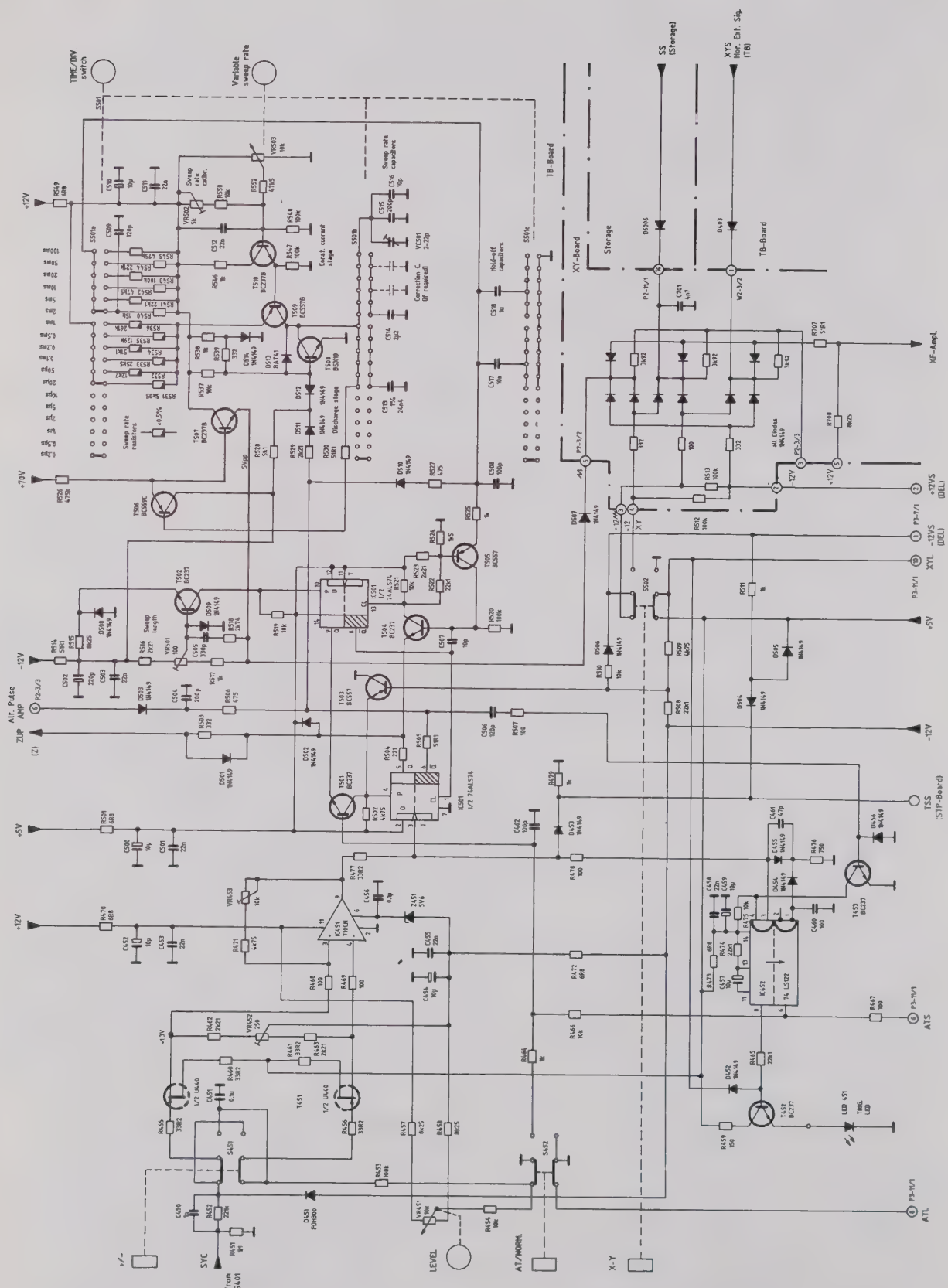


Änderungen vorbehalten / Subject to change without notice


+70V
D1
D2
+33V
T707 BF472
T708 BF458
T709 BF458
T710 BF472
T705 BF199
T706 BF199
T703 BF199
T704 BF199
T701 BC557
T702 BC557
T711 BC337B
T712 BC307B
+12V
-12V
+1.4V
+2.6V
-7.6V
-8.3V
+66.8V
0.7V
3.3V/Div.
0.5V/Div.
2.4mA
min. +0V
max. +60V
max. +6V
left +5.2V
center +2.6V
right +0.2V
min. -0.2V
* wired capacitor
X-MAG. x10
X-Pos.
ChP
PX
XY-Board
TB-Board
XYS from TB
Storage
SS
XYL
+5V
-12VS
+12VS
XY
+12XY
+12W
D701
D702
D703
D704
D705
D706
D707
D708
D709
D710
10x 1N4149
D403
D507
W2-3/2
P2-11/1
S201
S502

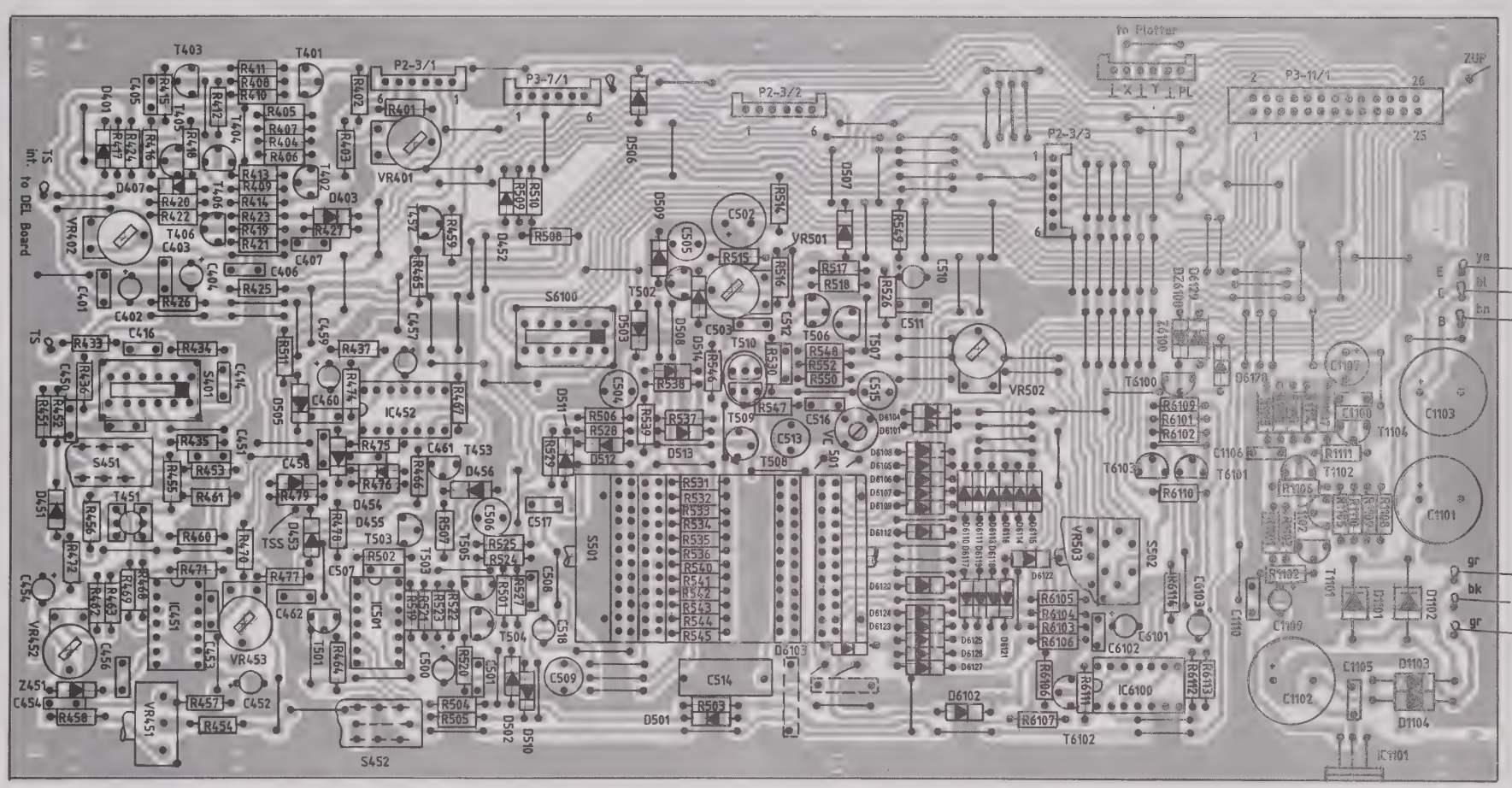
Trigger-Schaltung, Zeitbasis
Trigger Circuit, Timebase Circuit

HM208



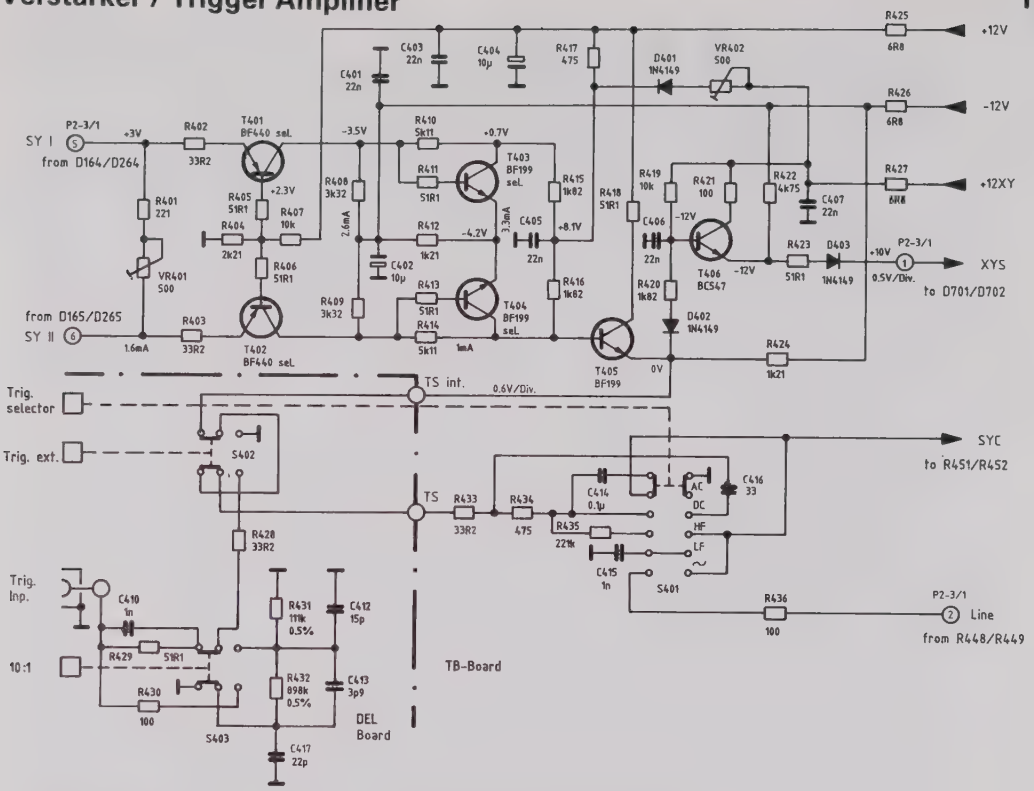
Änderungen vorbehalten / Subject to change without notice

Bestückungsplan TB-Board
Component Locations TB-Board

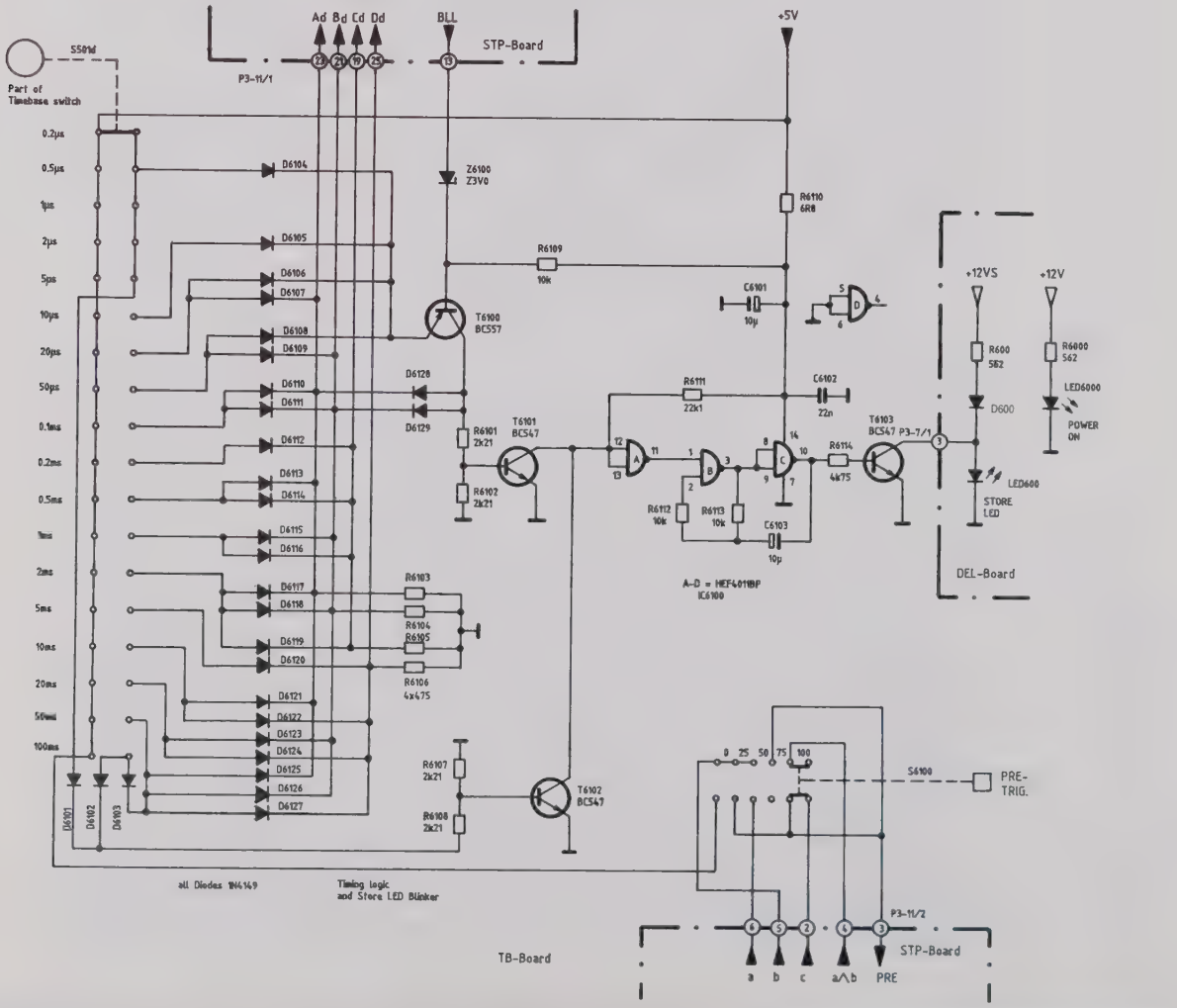


Änderungen vorbehalten/Subject to change without notice

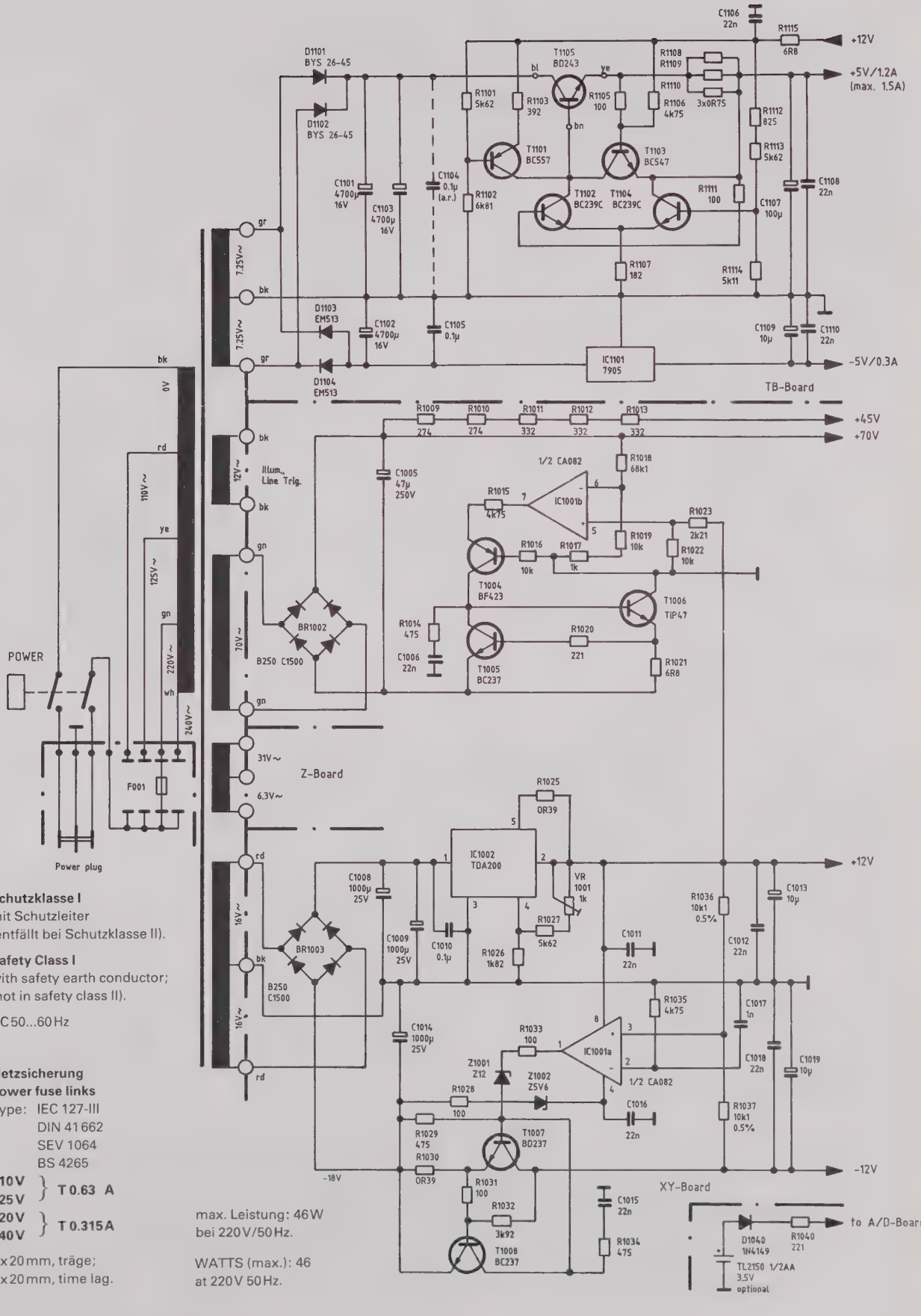
Trigger-Verstärker / Trigger Amplifier



Logik f. digitale Zeitbasis / Digital Timebase Logic



Änderungen vorbehalten/Subject to change without notice



Schutzklasse I
mit Schutzleiter
(entfällt bei Schutzklasse II).

Safety Class I
with safety earth conductor;
(not in safety class II).

AC 50...60 Hz

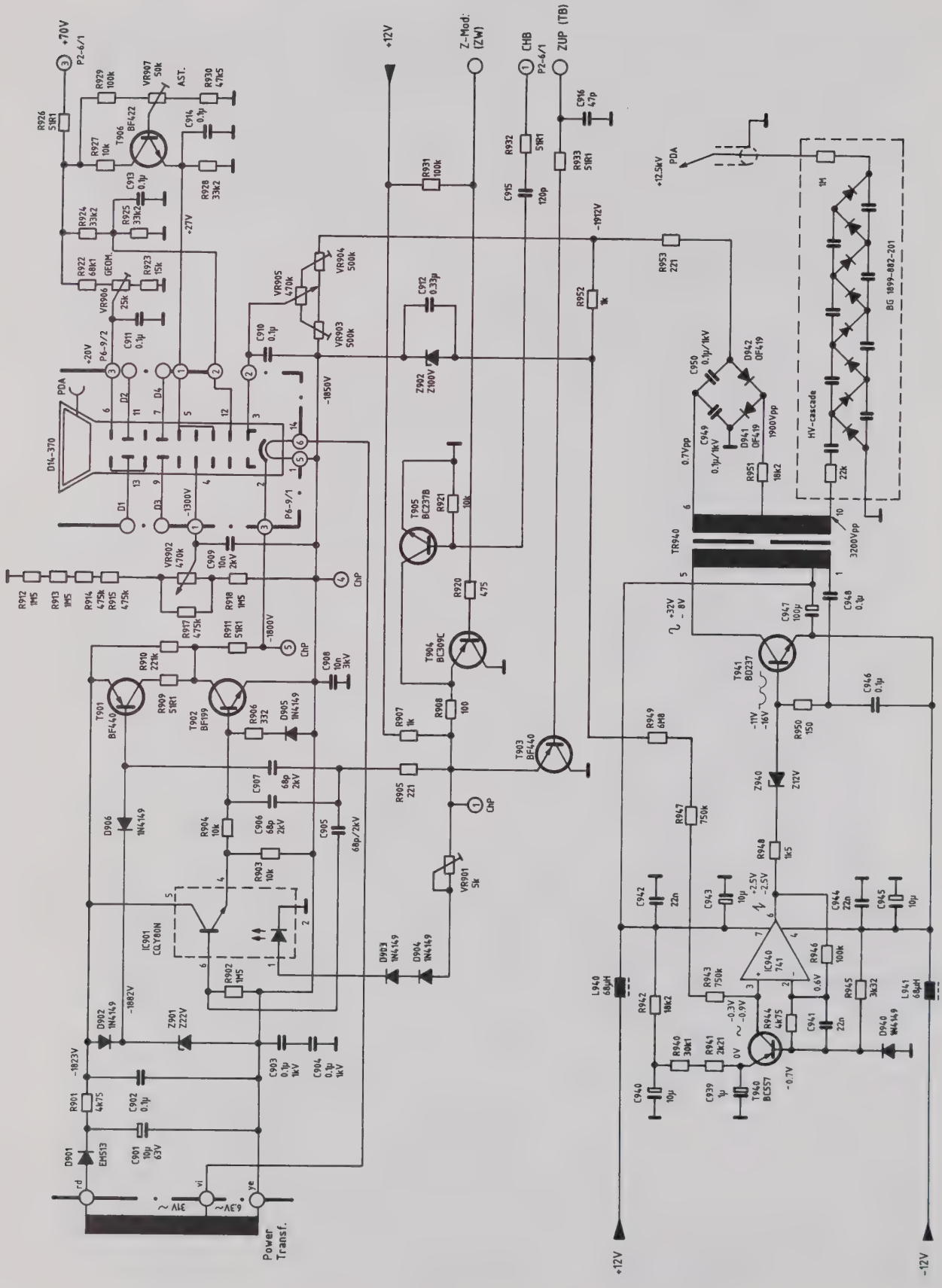
Netzsicherung
Power fuse links
Type: IEC 127-III
DIN 41 662
SEV 1064
BS 4265

110 V / 125 V } **T 0.63 A**
220 V / 240 V } **T 0.315 A**

5 x 20 mm, träge;
5 x 20 mm, time lag.

max. Leistung: 46 W
bei 220 V/50 Hz.

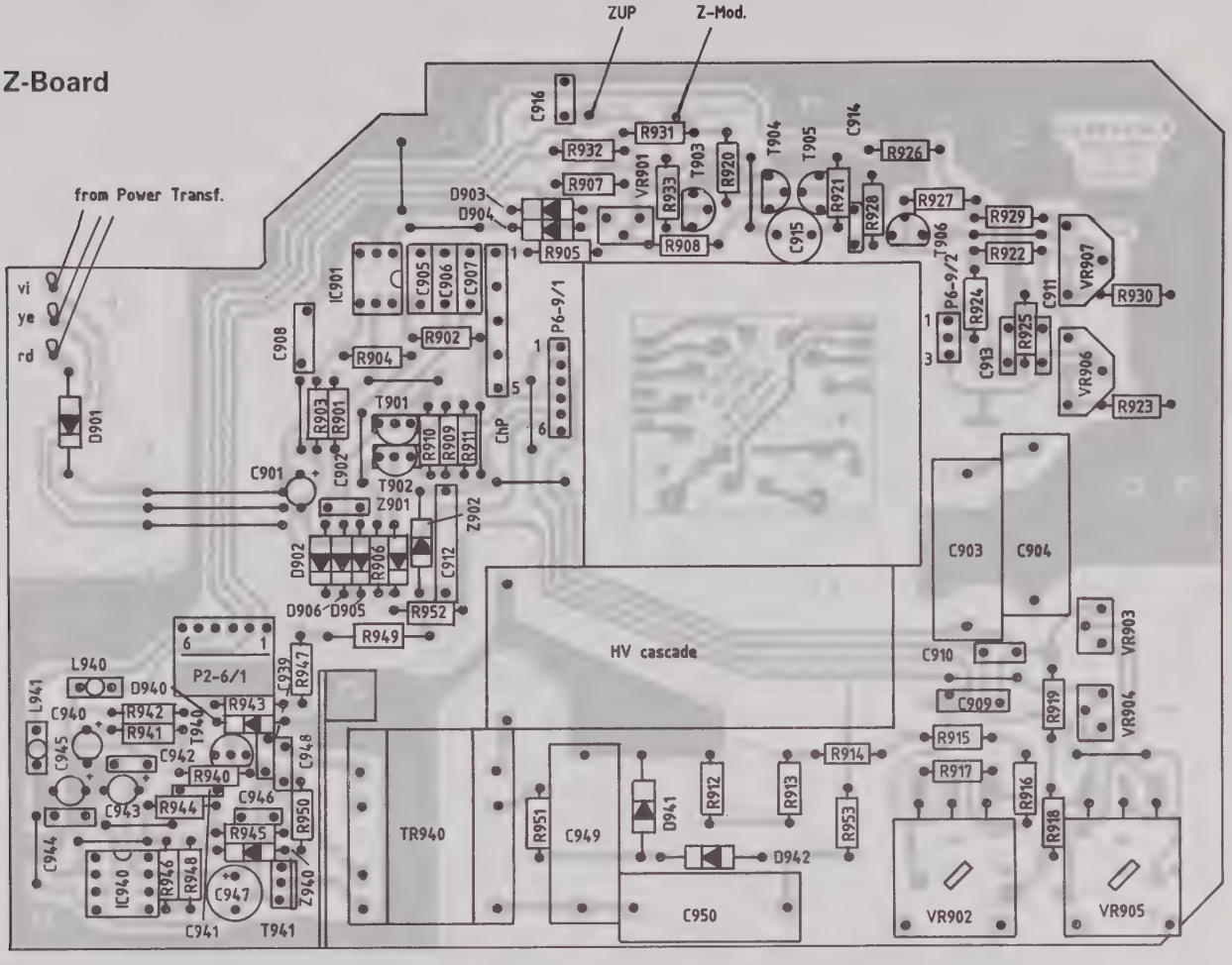
WATTS (max.): 46
at 220 V 50 Hz.



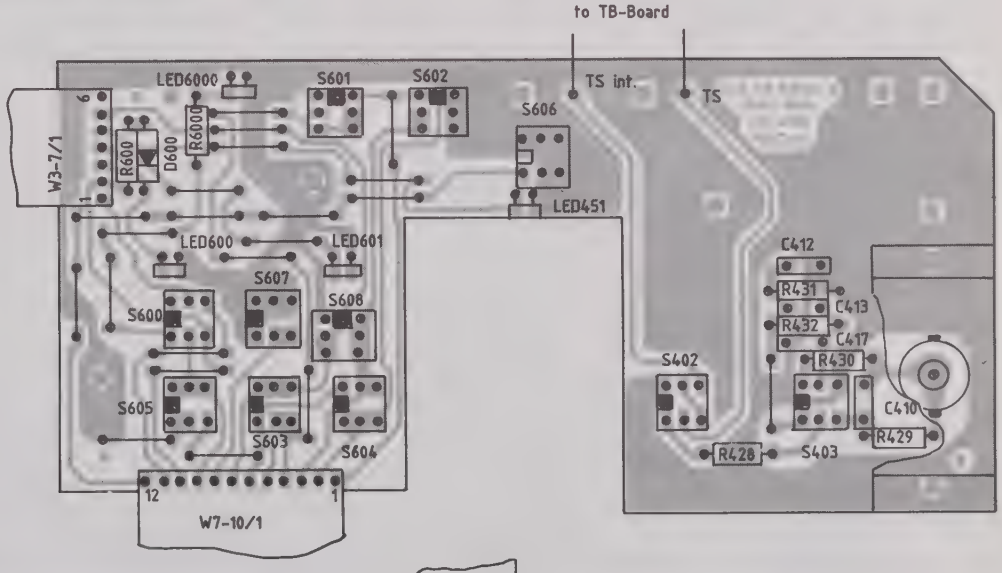
Änderungen vorbehalten/Subject to change without notice

Bestückungsplan: Z-Board, DEL-Board und TR-Board
Component Locations: Z-Board, DEL-Board, and TR-Board

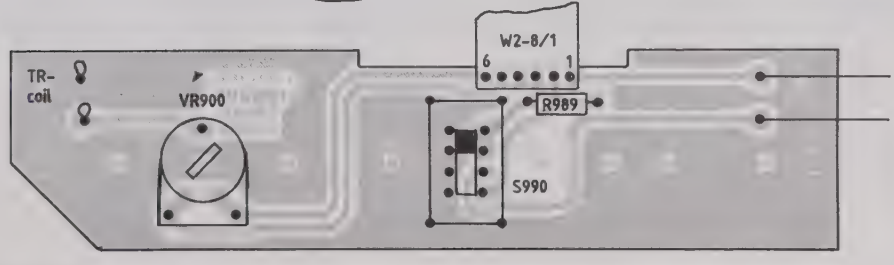
Z-Board

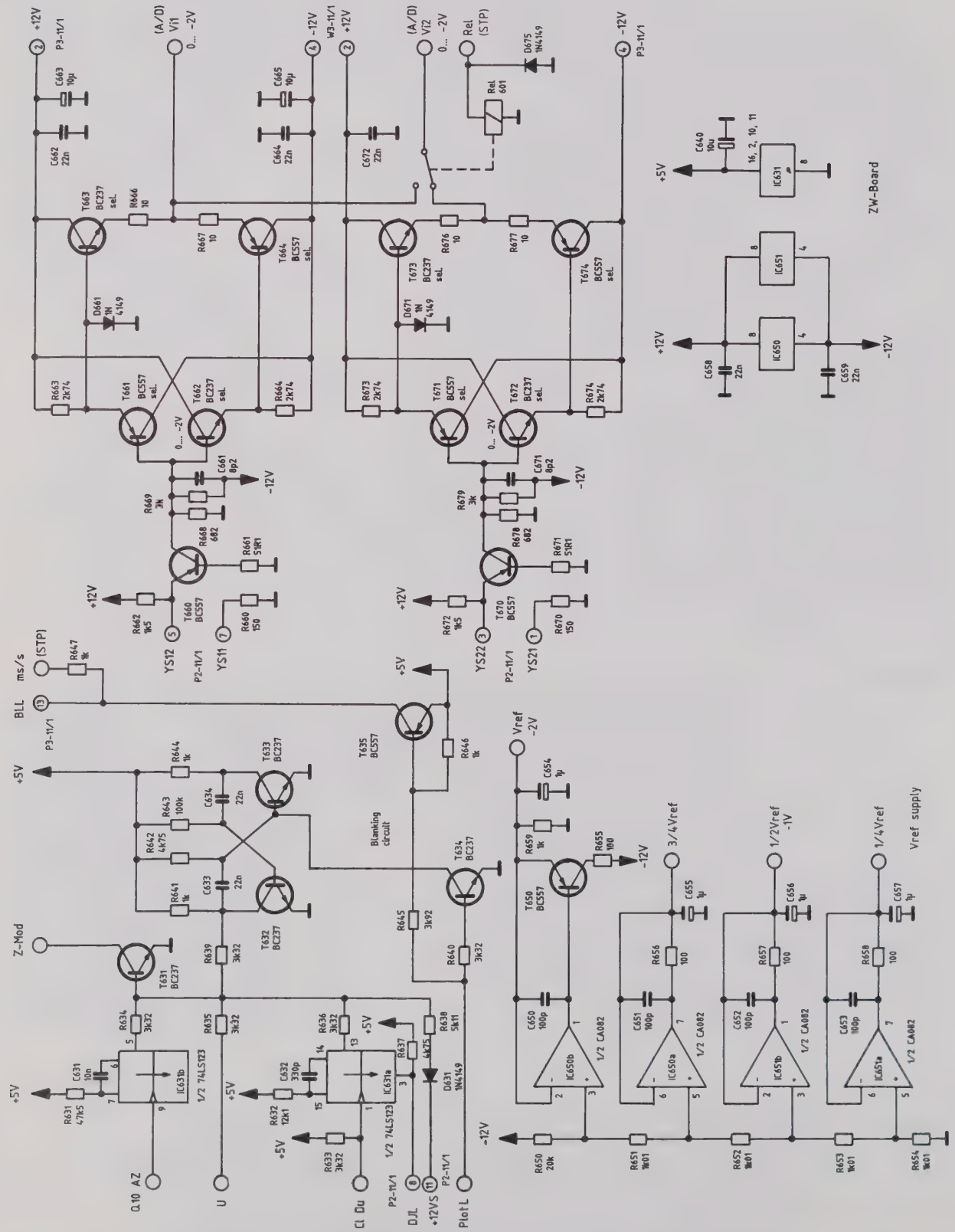


DEL-Board



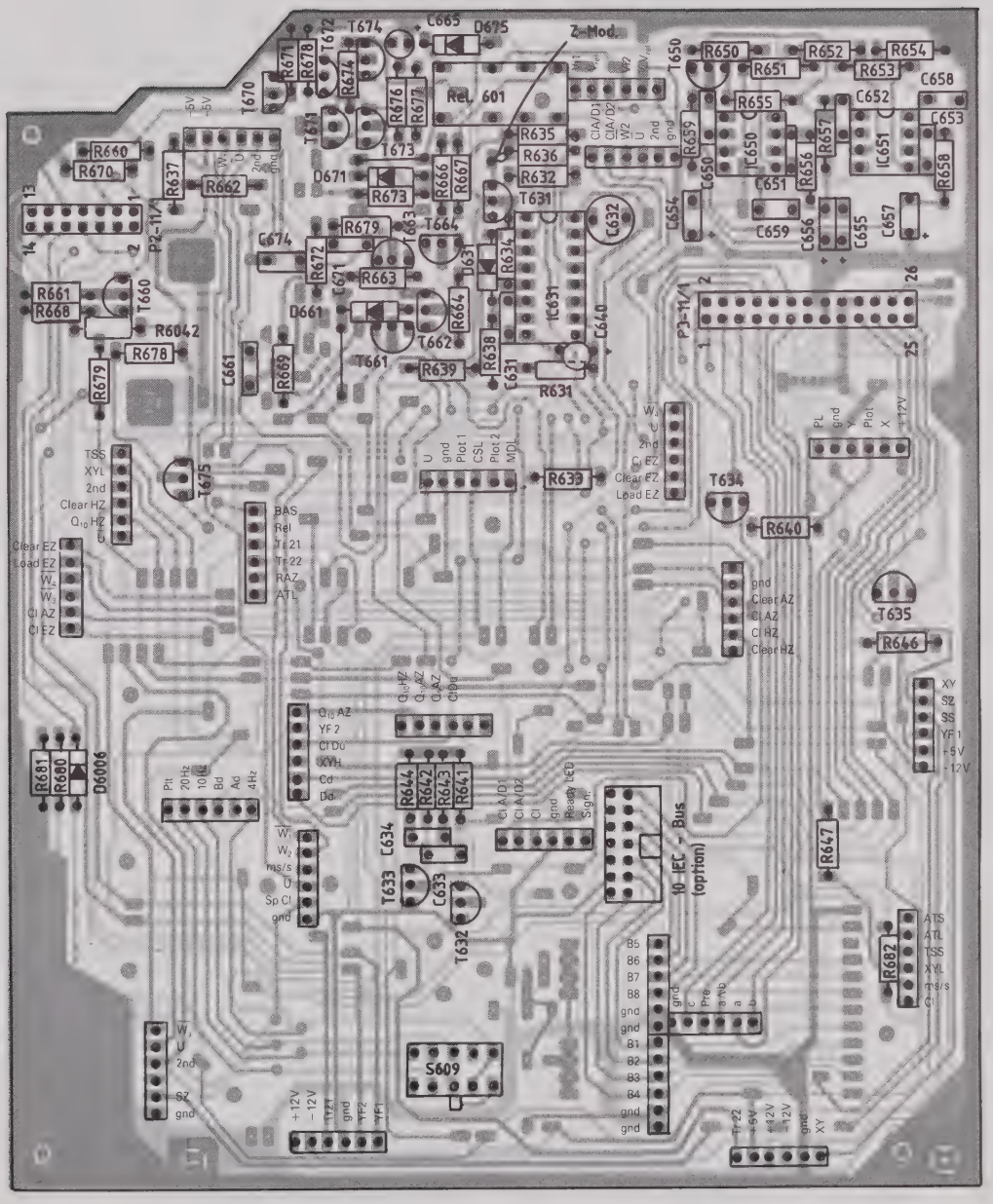
TR-Board

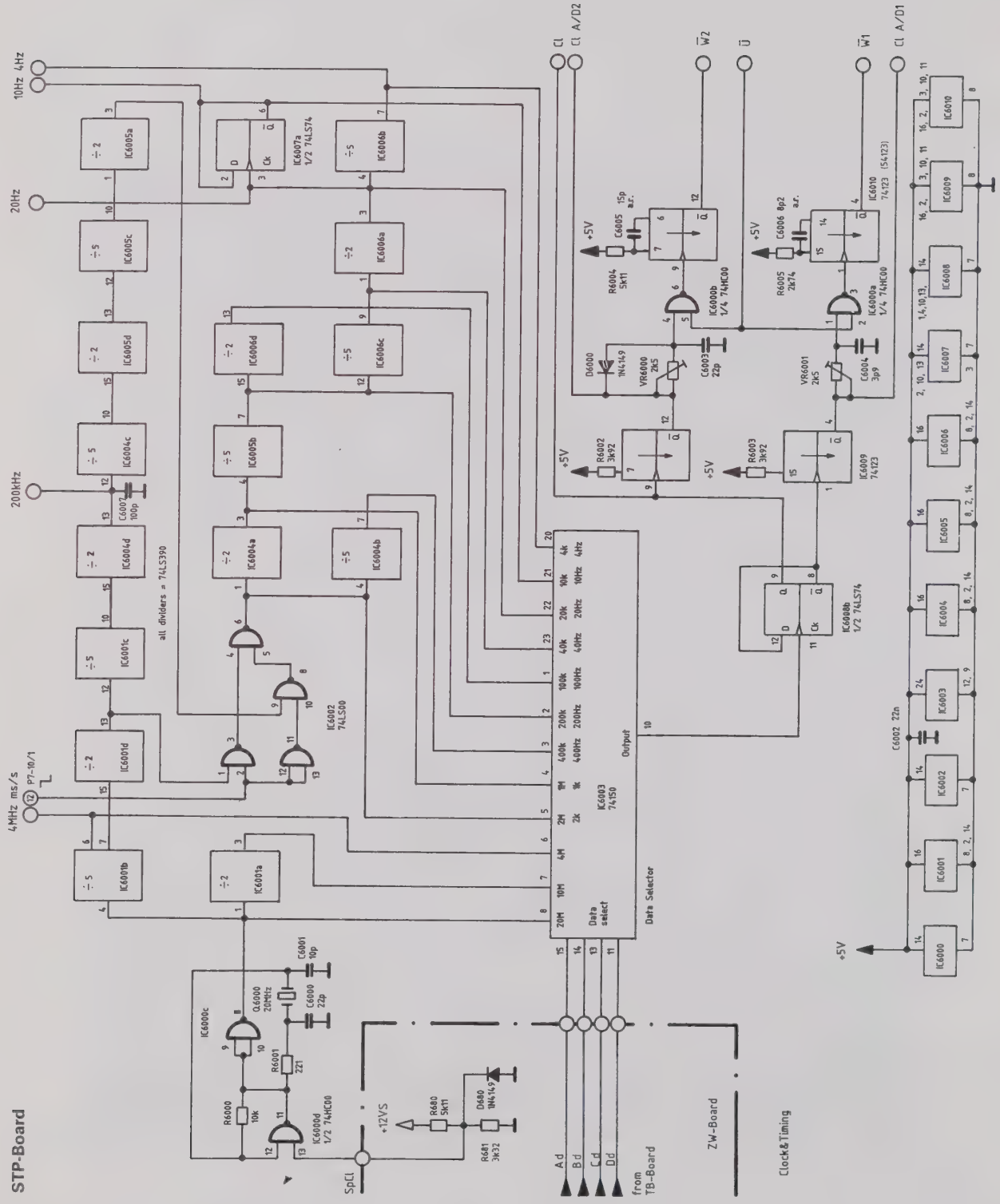




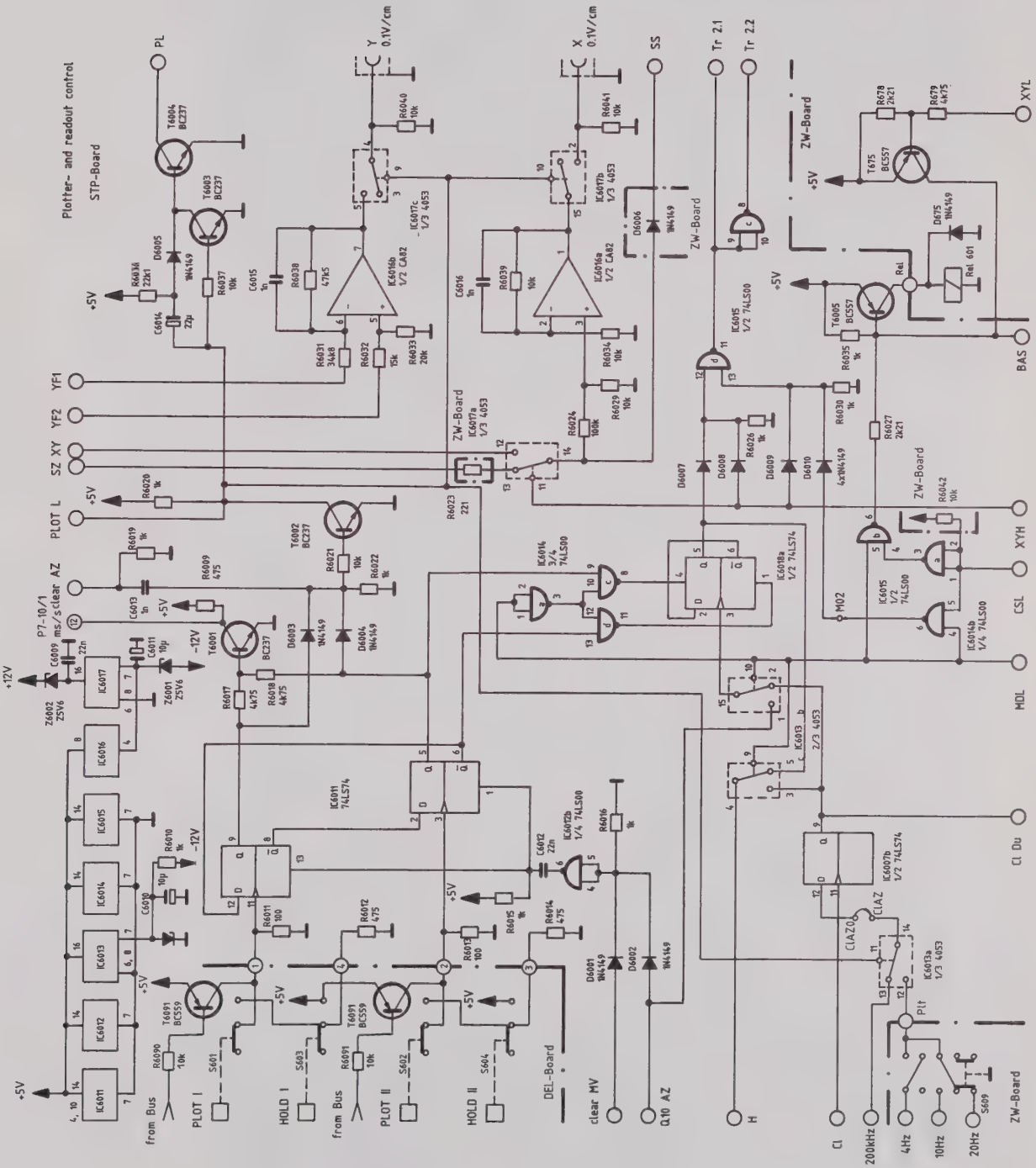
Änderungen vorbehalten / Subject to change without notice

Bestückungsplan ZW-Board
Component Locations ZW-Board

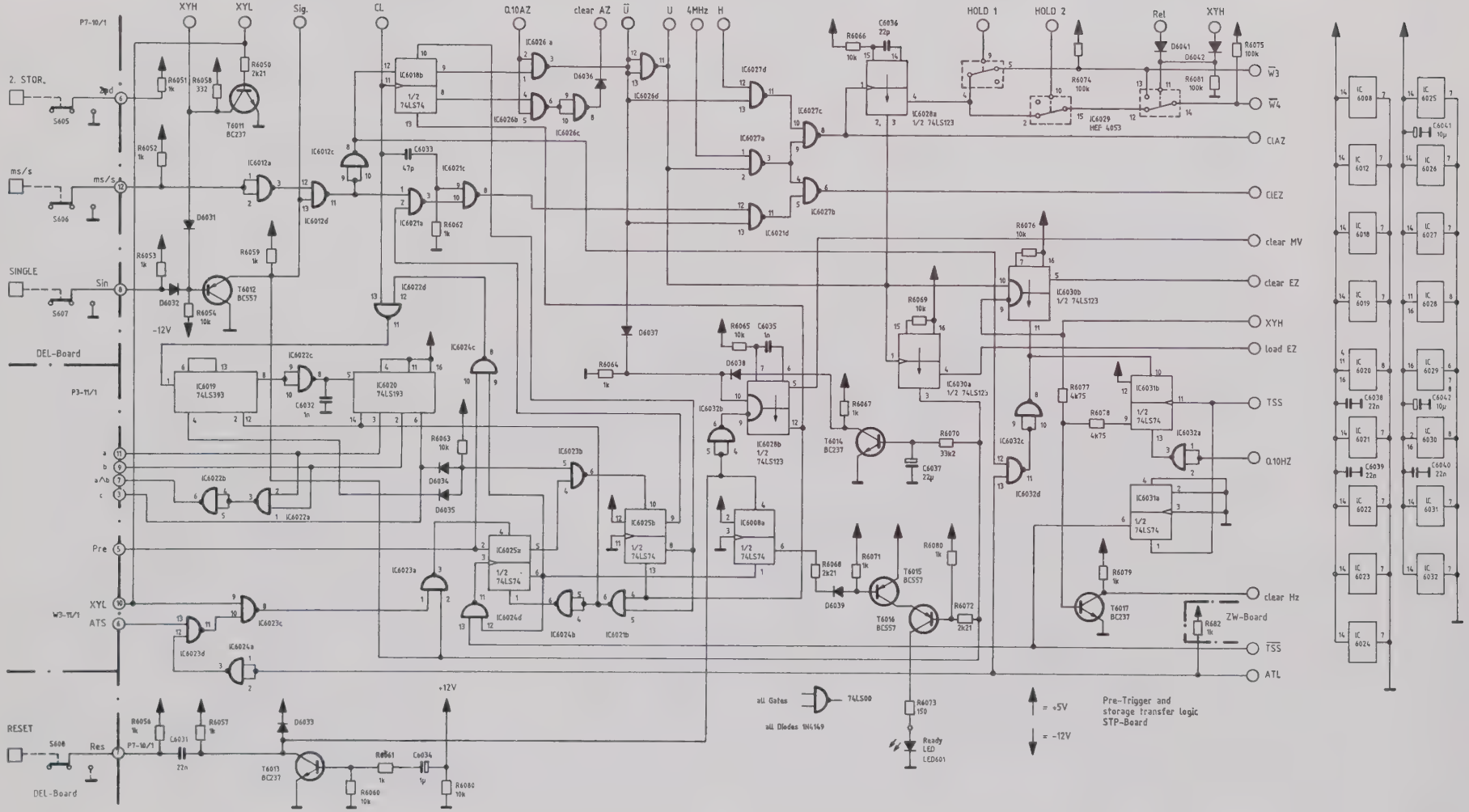




Änderungen vorbehalten/Subject to change without notice


Plotter- and readout control
STP-Board
PL
Y 0.1V/cm
X 0.1V/cm
SS
Tr 2.1
Tr 2.2
ZW-Board
XYL
BAS
YF1
YF2
SZ XY
PLOT L
AZ
P7_10/1
ms/s clear
XYH
CSL
MDL
Cl Du
M02
H
Q10 AZ
clear MV
DEL-Board
HOLD II
PLOT II
from Bus
HOLD I
PLOT I
Cl
200kHz
4Hz
10Hz
20Hz
Plt
+5V
+12V
-12V

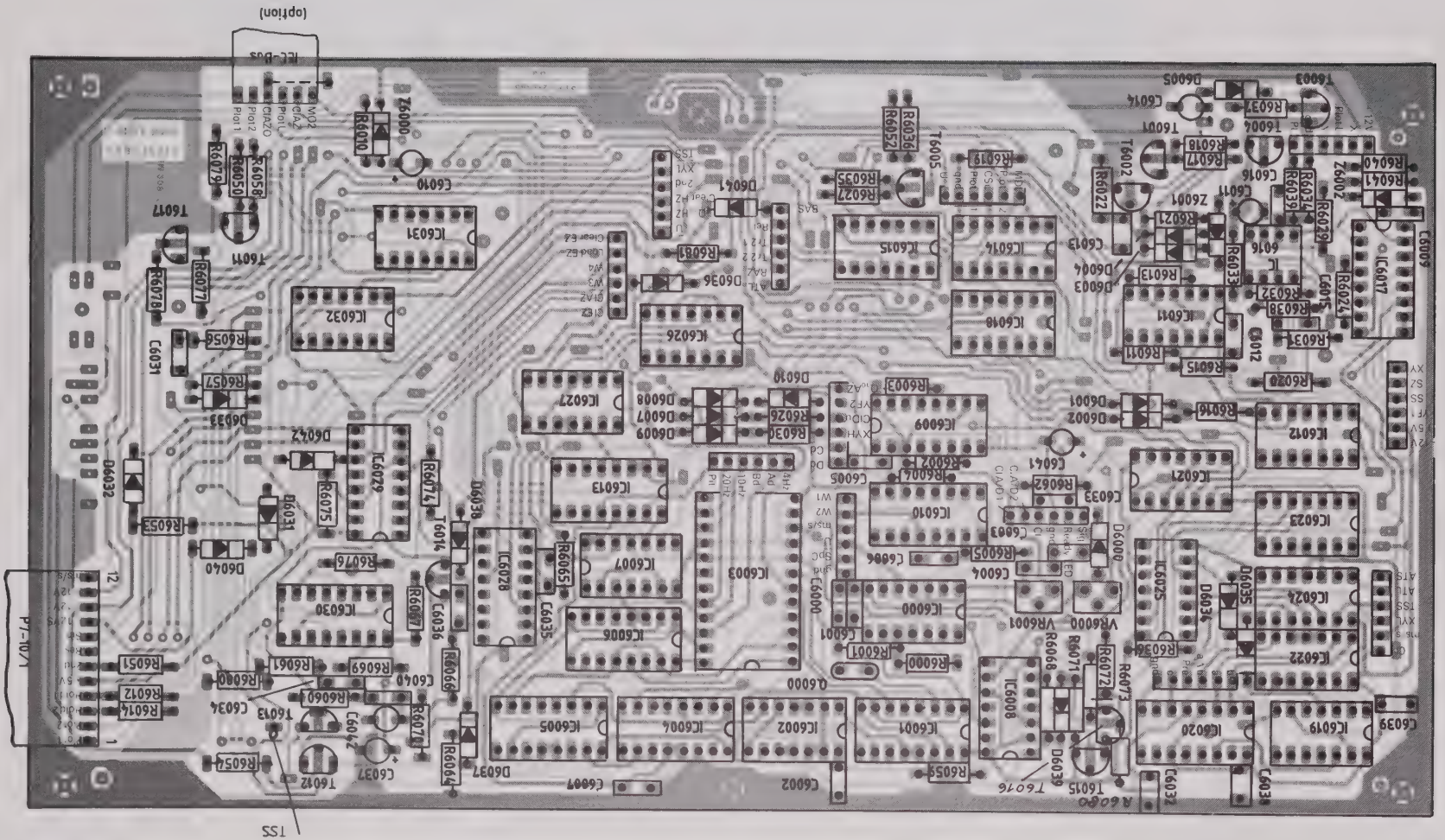
Pre-Trigger und Umspeicherlogik
Pre-Trigger and Storage Transfer-Logic



Änderungen vorbehalten/Subject to change without notice

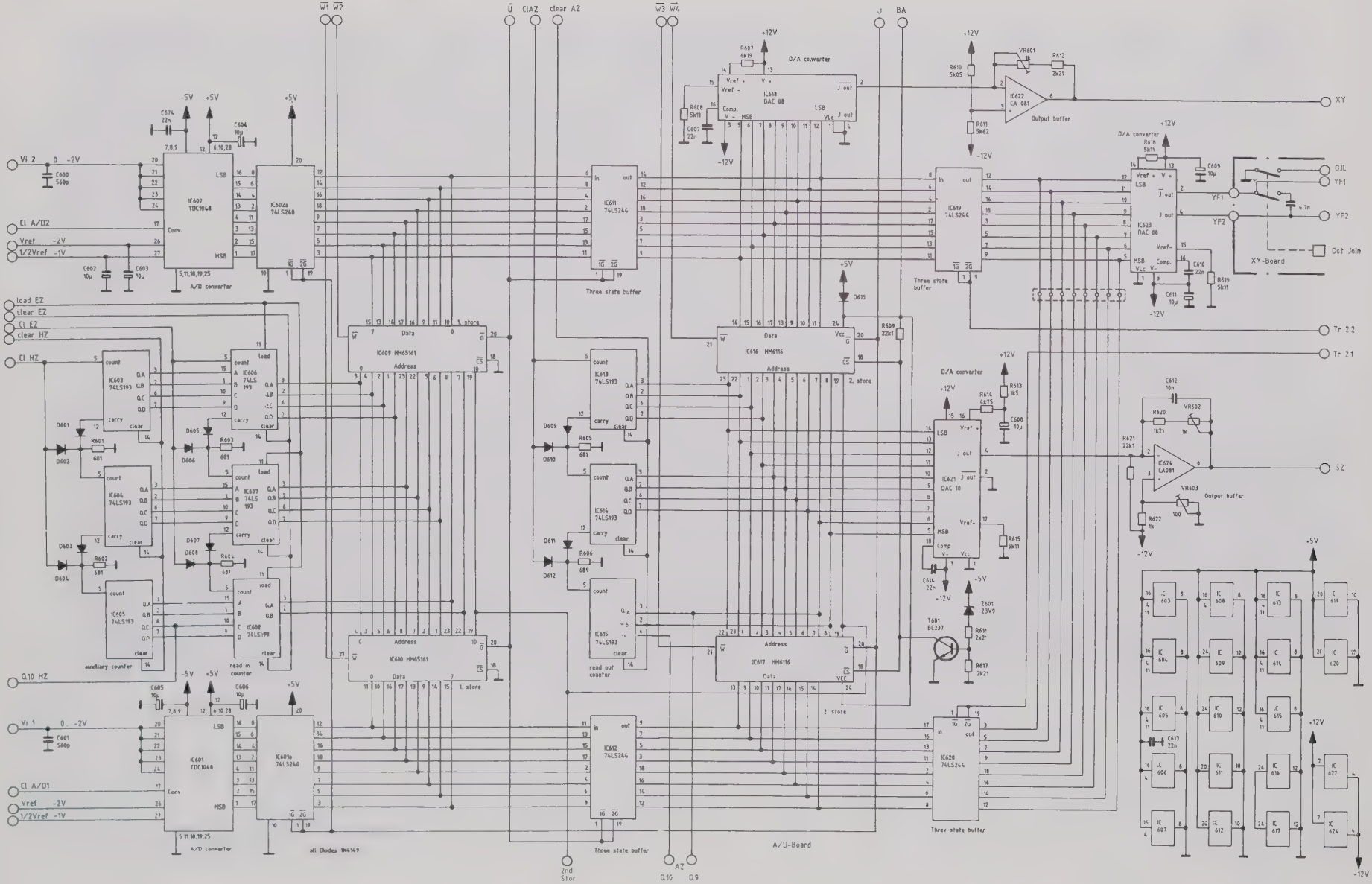
Bestückungsplan STP-Board
Component Locations STP-Board

HM208

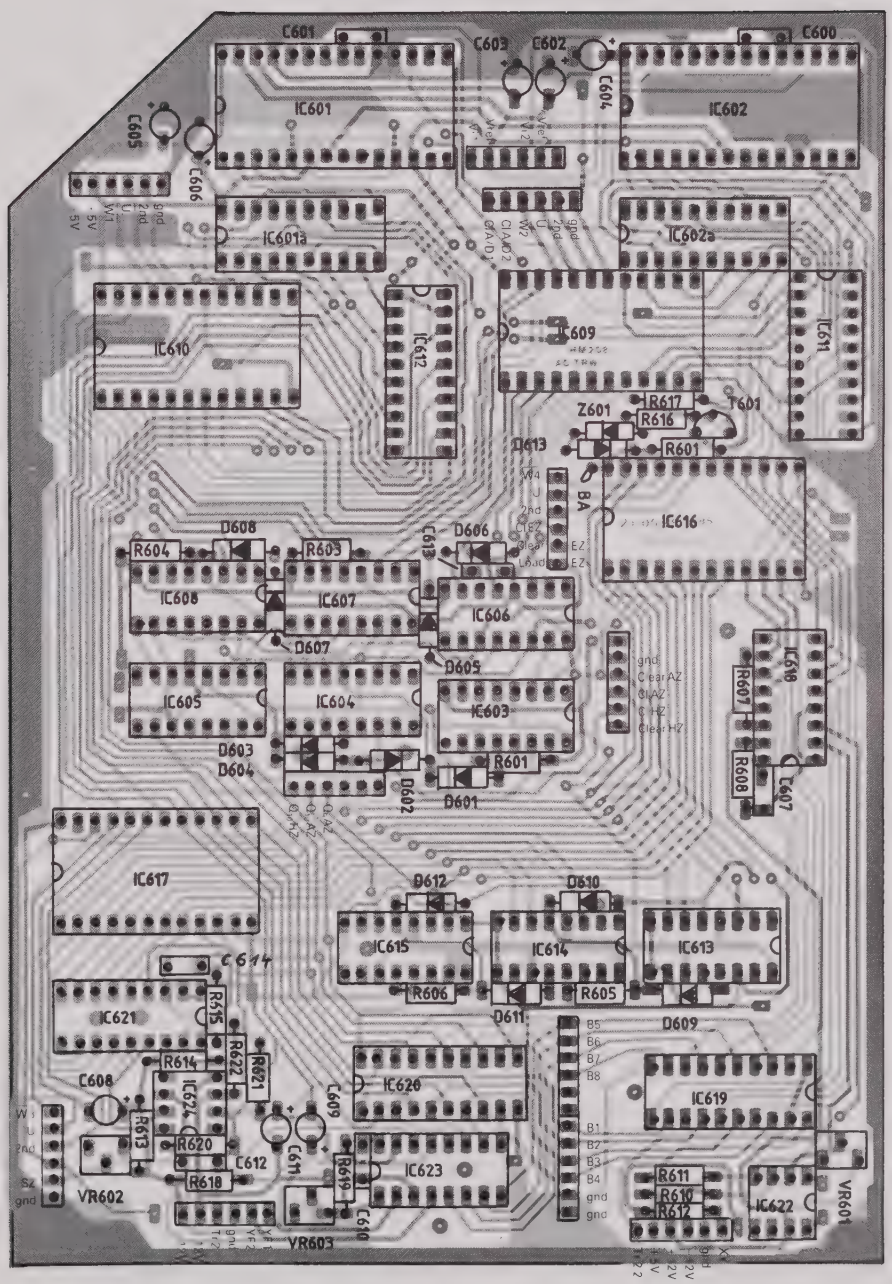


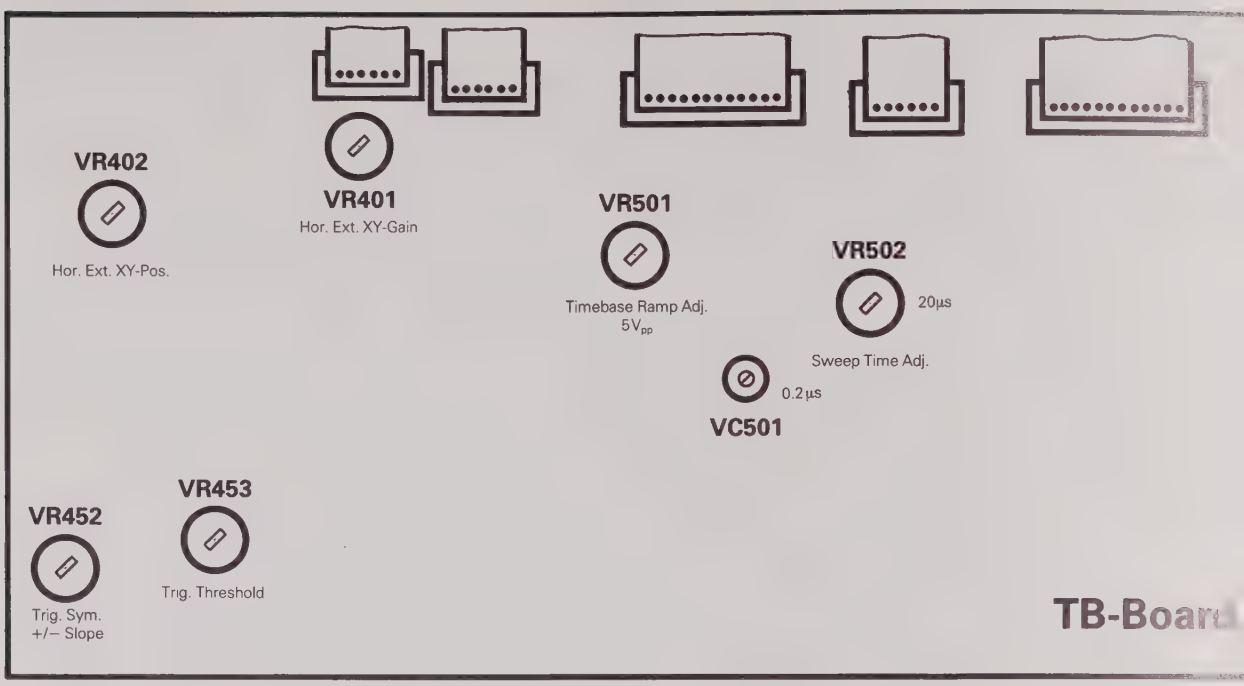
Änderungen vorbehalten/Subject to change without notice

A/D-Wandler
A/D-Converter

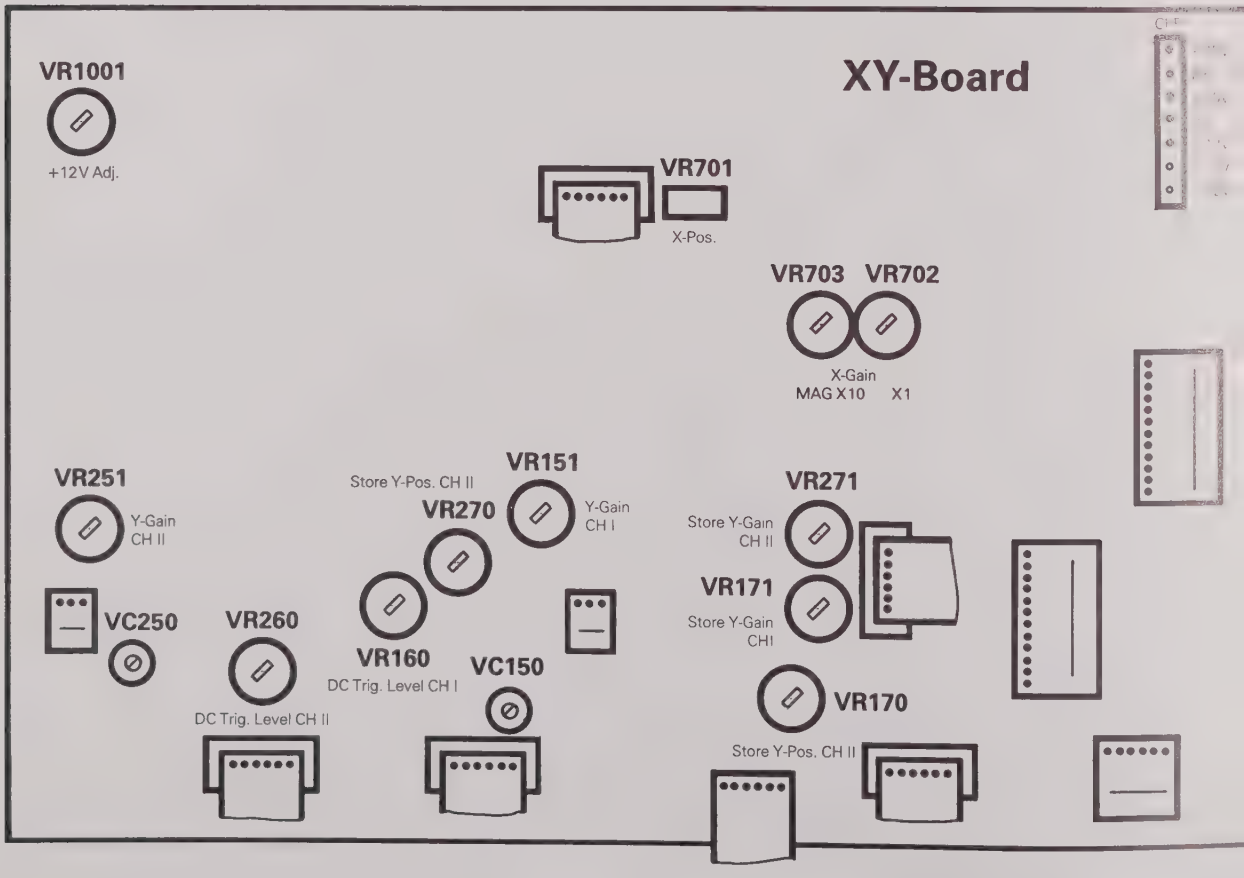


Änderungen vorbehalten/Subject to change without notice

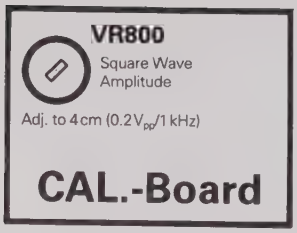

C601
C603
C602
C600
C604
C605
C606
IC601
IC602
IC601a
IC602a
IC610
IC612
C609
IC611
Z601
R617
R616
T601
D613
R601
IC616
D608
R604
R603
C613
D606
IC608
IC607
IC606
D607
D605
IC605
IC604
IC603
D603
D604
R601
D602
D601
IC618
R607
R608
C607
IC617
D612
D610
IC615
IC614
IC613
C614
R606
R605
D611
D609
IC621
R615
R622
R621
R614
C608
IC624
IC626
IC619
R613
R620
C612
C611
C609
R619
IC623
R611
R610
R612
IC622
VR601
VR602
VR603
C610

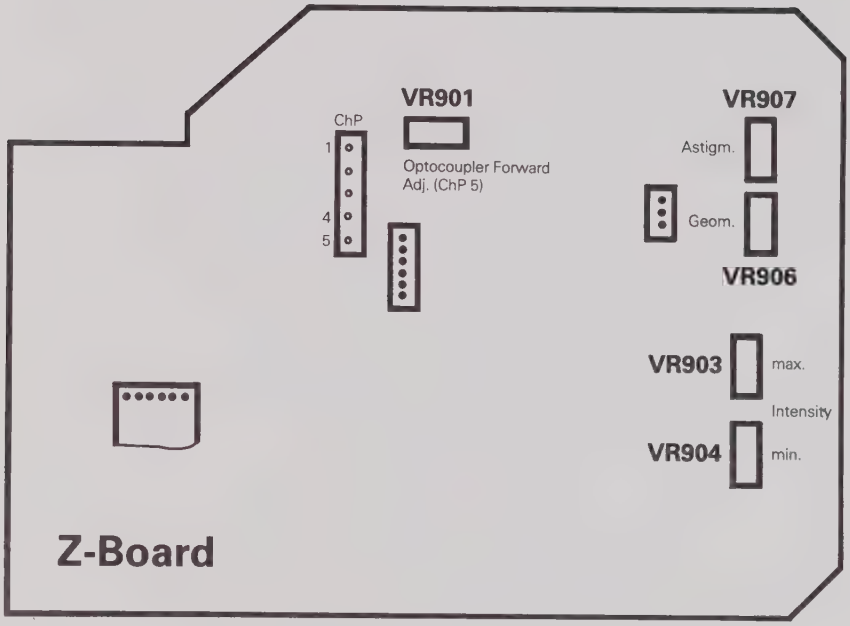


Adjusting Plan HM 208 (Analog.)

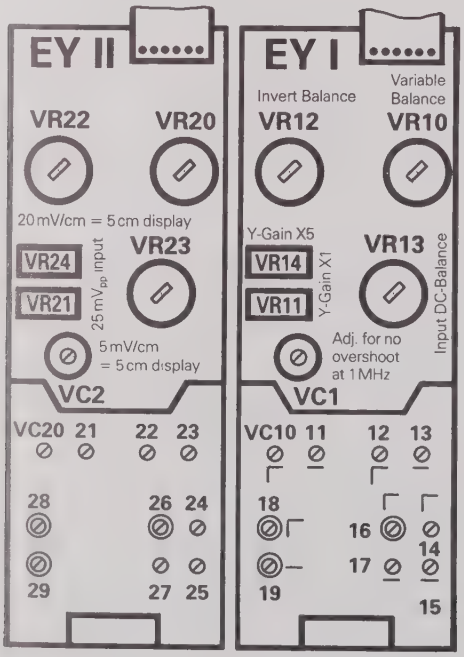


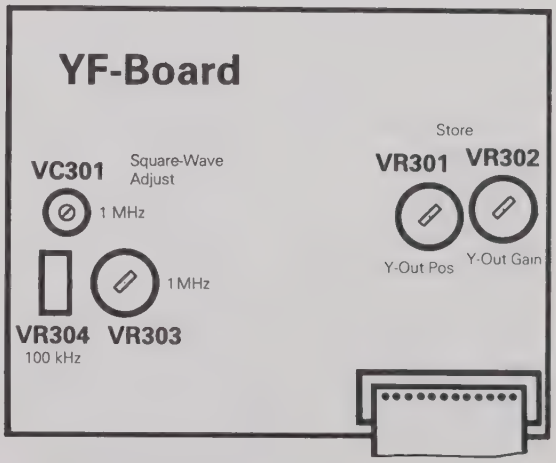
Änderungen vorbehalten / Subject to change without notice



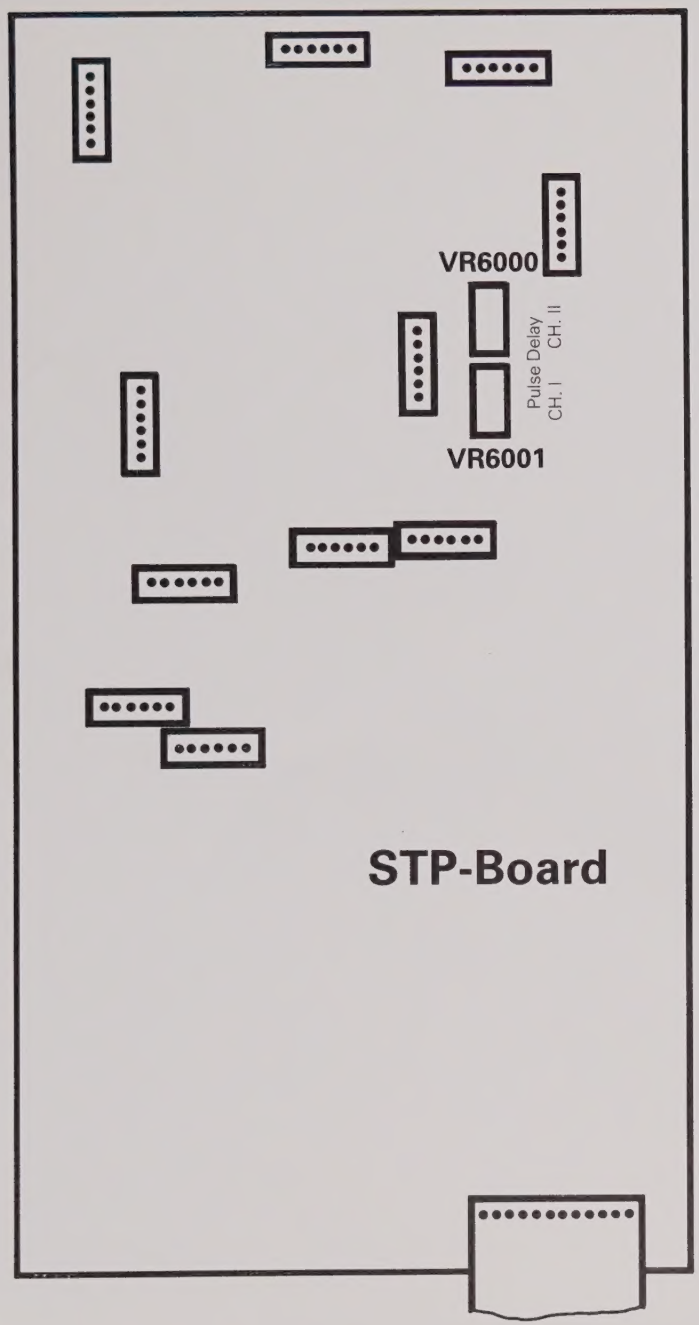


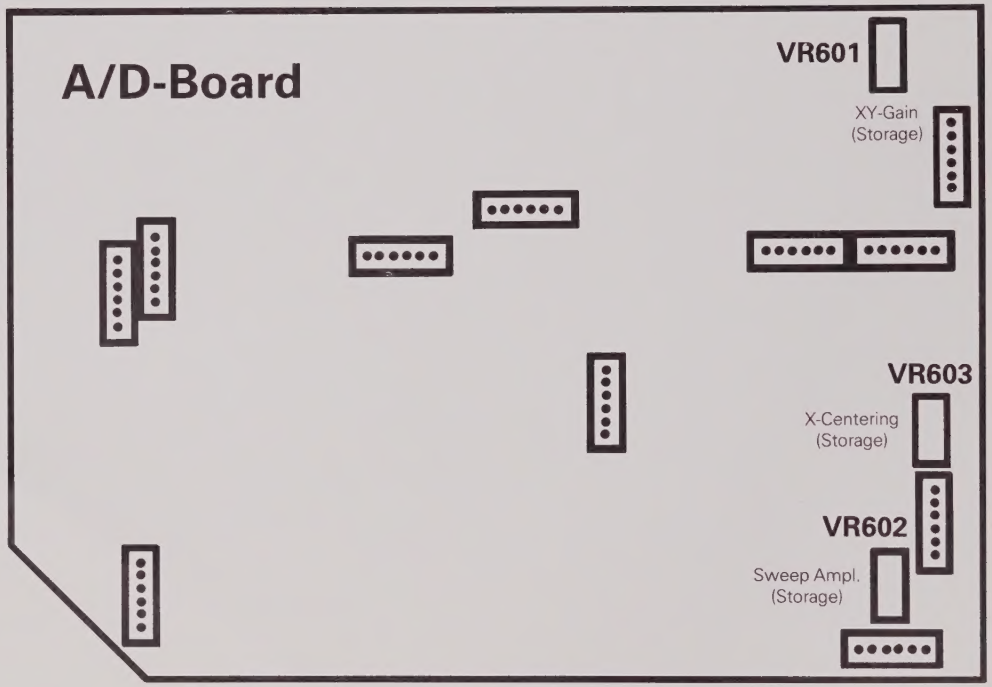
Attenuator adjustment:
– = horiz. flat top
= optimum corner
(leading edge)
⌊⌋ 1....5 kHz,
with Pre-Attenuator 2:1
and DC inp. coupling.
Generator amplitude:
preset defl. coefficient
(display height = 4 cm)





Adjusting Plan HM 208 (Dig.)





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